Millstone quarries in the south of the Iberian peninsula from Protohistory to Modern Times

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PART I

MILLSTONE QUARRIES IN THE SOUTH OF THE IBERIAN PENINSULA:
from Protohistory to Modern Times

To my family, Aurora Pulido, Erik and Jan Anderson,
and my parents Justice and Mary Ann Anderson

View of the millstone quarry of Moclín (GR-1, in the catalogue). This is the without a doubt the largest producer of millstones in the Province of Granada in the 19th century and probably the site alluded to in the Royal Decree of 1829.

Reales Decretos y Órdenes de 1829

"Habiendo acudido al Rey nuestro Señor don Marcelino Franco, del comercio de Pontevedra, pidiendo que se le permita la introduccion de cuarenta y dos piedras de moler trigo que dice ha comprado en el reino de Portugal; no ha tenido S. M. á bien acceder á esta solicitud, respecto á que se halla prohibido dicho artículo por el Arancel vigente, en razon á las muchas canteras que hay en diferentes Provincias de España; ***principalemente en la de Alava, en Granada y otros parages de Andalucía,*** *de donde se sacan con abundancia cuantas piedras se necesitan para dicho objeto."*

Reales Decretos y Órdenes de S. M. que producen resolución general en su Real Hacienda expedidos en el año de 1829. (Extracto de FERRER, Narciso1830: 219).

Royal Decrees and Orders of 1829

"Don Marcelino Franco, merchant of Pontevedra, presented to our Lord the King the request to import forty-two flour millstones reputedly acquired in the kingdom of Portugal; H. M. has refused the request, because of the Law forbids the import of this article due to the many millstone quarries in different provinces of Spain, ***chiefly in Alava, in Granada and other locations of Andalusia****, where all the needs are met by the abundant exploitation of these stones".*

Royal Decrees and Orders of H. M. the King in 1829 pertaining to the Royal Treasury (from FERRER, Narciso. 1830: 219).

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1. INTRODUCTION

1.1. Millstone quarries everywhere

Before the current commercial network producing bread far from where it is consumed, wheat and other cereals were ground and baked locally. Throughout history, after the phases of harvesting and storing, grains had to be ground for consumption, an activity that took place in different types of mills driven by man, animal, water or wind. The evidence of millstones from the early days of the agricultural revolution of the Neolithic to very recent history is widespread in southern Spain as seen through querns and millstones collected on archaeological excavations or large millstones decorating public spaces.

The first grinding tools were the saddle-shaped querns, driven with a to-and-fro movement. With the advent of the Iron Age came the circular querns and millstones driven by a rotary motion, a technological advance that was developed further in Antiquity with the introduction of more sophisticated animal-driven or water-driven mills. Owing to hydraulic the engineering capabilities of Spanish Muslims, watermills were widespread in southern Spain in the 8th and 9th centuries (Imamuddin 1981: 107). Closer to our times, the geographer Muhammad al-Idrisi, toward the middle of the 12th century, describes four buildings over the Guadalquivir River in Córdoba, each containing four mills (Martínez 1987-1988: 226). H. Swinburne, in his book of travels, quotes the translation of an Arabic text by Abi Abdaalah ben Alkalhibi Abianeni from 1378 describing the surroundings of Granada a century before the fall of Islamic domination: "I have heard the names of above three hundred hamlets in the environs of Granada: within sight of the city walls may be reckoned fifty colleges and places of worship, and above three hundred water-mills" (Swinburne 1787: 257-258). The *Repartimientos* of Valencia, land registers penned in the initial phases of the Christian Reconquest, record more than a hundred transfers of mills to Christian settlers (Glick 1994: 982). In light of all the evidence of scores of mills, one can wonder where all the millers acquired the thousands of hard, compact and abrasive millstones that played such a fundamental role in the daily nutrition of man.

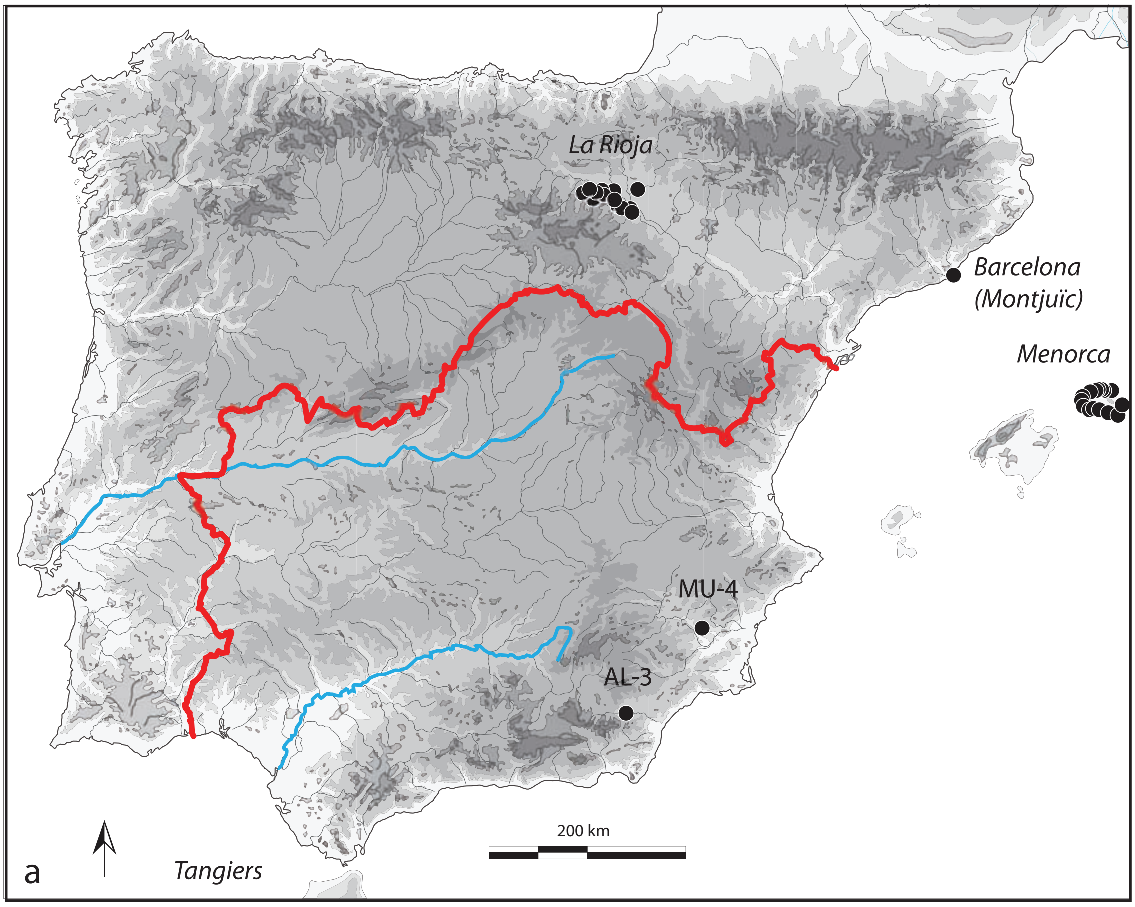
Even more specifically, the 19th-century geographical dictionaries of Sebastian Miñano (1826-1829) and Pascual Madoz (1845-1850) record the presence of mills in almost every village in Spain, not to mention the larger towns and cities (see annex 3 for specific references). K. Lizarralde, in his quantification of the milling installations recorded by Madoz, has itemised 22,492 flour watermills, 676 windmills and 1476 *tahonas* (animal-driven flour mills) (Lizarralde, 2010, http://murcia.mu/~molinosa/wp-content/uploads/2012/05/MADOZ-KOLDO.pdf). If we take the total number of the flour mills counted by Lizarralde and double it (based on two millstones per mill), we attain a number near 50,000 millstones for the middle of the 19th century. This, of course, is a minimal count because most milling installations possessed more than one pair. Moreover, millstones at this time also were not characterized for their longevity because they had to be dressed, in some cases, on a quotidian basis. In any event, owing to the huge demand, millstones production centres of the 19th century must have been countless and widespread.

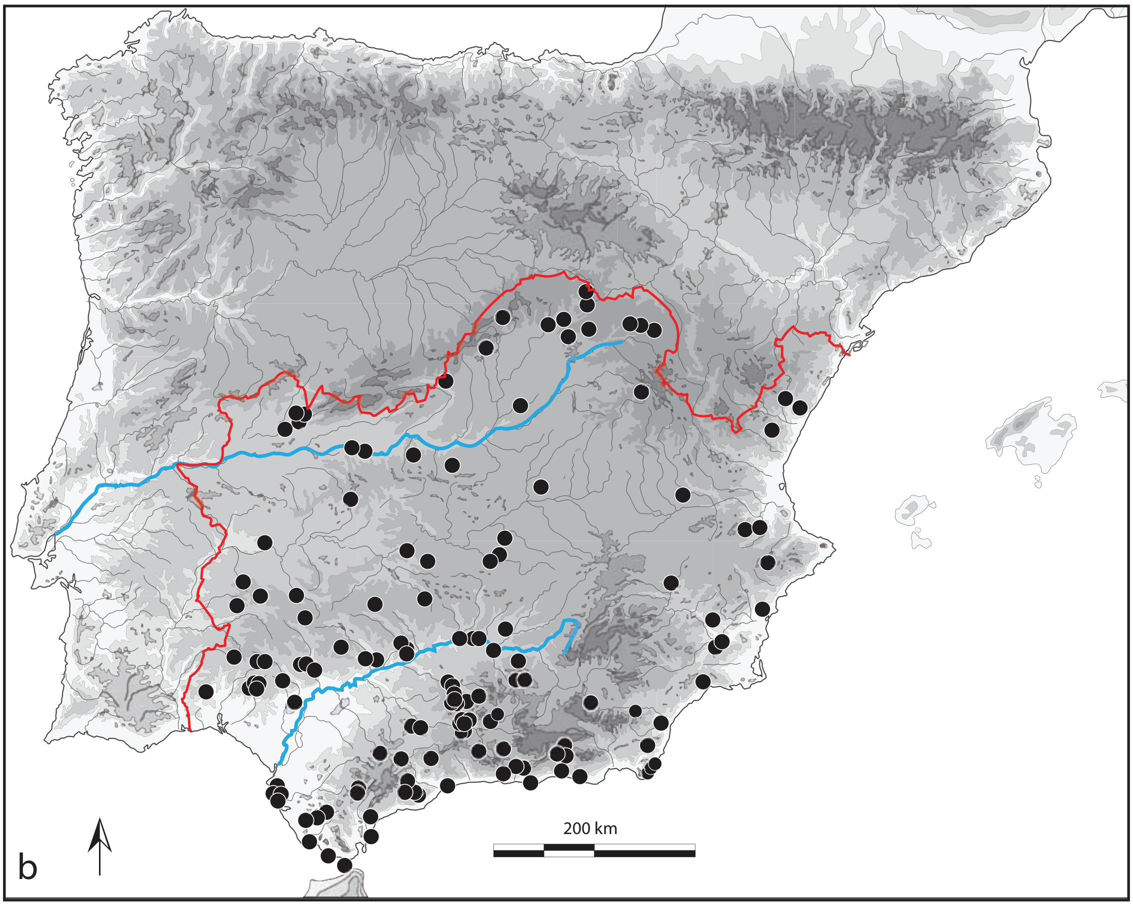
It must be noted that at the time that the dictionaries of Madoz and Miñano were penned, the Industrial Revolution had not yet reached Spain, and the Peninsula was still without a railway network. French siliceous stones from the quarry districts such as La Ferté-sous-Jouarre in the Paris Basin, deemed the best in the world because of the fine, white flour they yielded, and soon to dominate the European millstone market of bread millstones, were yet to be introduced on a large scale in Spain. Spanish millers were therefore obliged to turn to local and regional quarries for their millstones, which also explains their ubiquity across the Iberian landscape in the 19th century.

The situation of Spanish millstone quarries changed in the second half of the 19th century with first the arrival of French millstones and then the abandon in the 20th century of the traditional bread mill. These often spectacular sites, owing to their high faces at times marked with of multiple tubular extraction hollows, have for the most part fallen into ruin. They are abandoned, often overgrown by vegetation, and even converted into dumping grounds, or worse, destroyed by modern construction. This is the case of the Montjuïc near Barcelona, once one of the largest and most celebrated millstone quarries in the western Mediterranean basin. The neglect of this heritage is also reflected even in the scientific community. Whereas watermills and windmills have recently attracted an immense amount of attention and rivers of ink, specialists have remained virtually mute on the quarries that equipped the mills with millstones. This neglect is especially visible in the south of Spain, our study area, as seen by the spread of sites identified in specialised articles before and after we began our research in 2007 (fig. 1.1- fig. 1.2).

It is therefore our intent to undertake this first comprehensive balance of millstone quarries in the southern half of the Iberian Peninsula, a heritage mostly forgotten and now often in danger of destruction from both man and nature. It is a definitely a heritage worth conserving with many much scope and ramifications. As a millstone quarry specialist has recently noted in the summary of a book: "Whereas ancient churches tell the story of religious beliefs, and ruins of castles evoke bygone the power of the elite, millstone quarries are monuments to the glory of work and everyday life" (Belmont 2006).

Fig. 1.1 (Opposite page): Maps of the Iberian Peninsula indicating a) the millstone quarries identified in research previous to our study and b) the current spread of 138 millstone quarries (or millstone production districts) in the souther half of the Peninsula. The concentration of sites in the upper map in the Province of La Rioja is the work of Pilar Pascual Mayoral and Pedro García Ruíz (e.g. Pascual & Ruíz 2011). The second concentration on the Balearic Island of Menorca is the work of Joaquín Sánchez Navarro (e.g. Sánchez Navarro 2011). Only two sites were published in our study are before or at the outset of our research in 2007: AL-3, Cantera de la Rambla Honda (Martínez & Granero 2005);and MU-4, Fortuna (Matilla Seiquer 2001).


La Rioja
Barcelona
(Montjuïc)
Menorca
MU-4
AL-3
200 km
a
Tangiers


200 km
b

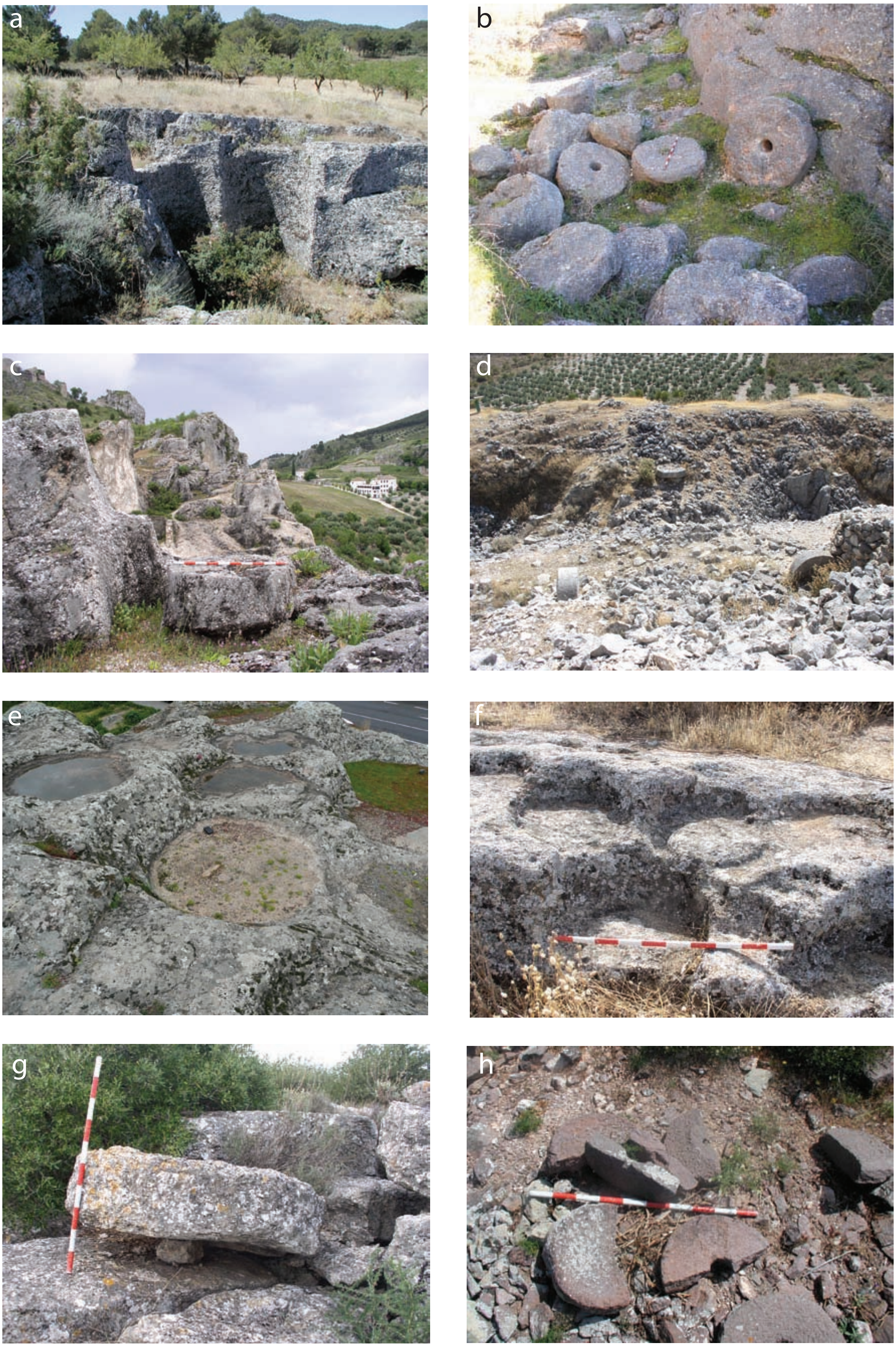


Fig. 1.2: Examples of millstone quarries in southern Spain: a) Los Guillares, Padul, Granada (GR-7); b) Cantera de los Frailes, Cabra (Córdoba) (CO-1); c) Cantera, Moclín (Granada) (GR-1a); d) El Lachar, Jimena (Jaén) (J-2); e) Plasencia (Cáseres) (CC-12); f) Zagra (Granada) (GR-5); g) Teba (Málaga) (MA-2); and h) Cerro Limones (Almería) (AL-1). The codes after the name of each site refer to the catalogue at the end of this work.

1.2. Study area

The area under study comprises six different autonomous communities, corresponding roughly to the southern half of Spain (fig. 1.3). These include Andalusia, Murcia, Castilla La Mancha, Valencia, Extremadura and Madrid. With the exception of Madrid (M) and Murcia (MU), the communities are sub-divided into provinces: **Andalusia**: Granada (GR), Almería (AL), Jaén (J), Córdoba (CO), Málaga (MA), Cádiz (CA), Seville (SE), Huelva (HU); **Castilla La Mancha**: Ciudad Real (CR), Albacete (AB), Toledo (TO), Cuenca (CU), Guadalajara (GU); **Valencia**: Alicante (A), Valencia (V), Castellón (CS); **Extremadura**: Badajoz (BA) and Cáceres (CC). These abbreviations, in conjunction with a number (e.g. GR-1), are used in the catalogue at the end of this work to identify the different millstone quarries. Hence, GR-1 is the code of site 1 of the Province of Granada (see catalogue).

From a geographical standpoint, the area comprises a large sector of the Inner Plateau, the Sierra Morena mountains, the Guadalquivir River Basin and the Betic mountains. To the west, the area reaches the Portuguese border, while to the southwest and southeast, the area is bordered by the Atlantic Ocean and the Mediterranean Sea. Its northern border corresponds roughly to an east-west line, the Tagus River that flows from east to west. The provinces of Guadalajara and Castellón, the northernmost provinces of the autonomies of Castilla La Mancha and Valencia, as well as Madrid, are included because they include a number of key sites from the historical and petrographical point of view.

Fig. 1.3: Map of the southern half of the Iberian Peninsula with the borders of the six autonomies and their respective provinces (abbreviated). Indicated also are localities referred to throughout the text (Brañosera in the Palencia Mountains, Montjuïc by Barcelona and Macael in Almería).

1.3. Previous research on Iberian millstone quarries

As mentioned before, contrary to research on modern and contemporary mills, in particular watermills, little work has focused specifically on the quarries where millstones were extracted. The first scientific study of this type of quarry in Spain, at the Cerro Redondo in Zaragoza (Cisneros *et al.* 1983) has the merit of including geological analyses, but the authors did not consider the possibility that the porphyric granite extractions, ranging between 60 and 80 cm in diameter, could be anything else but column drums. Since that publication, millstone quarry research has taken place in the last decade. P. Pascual and P. García in the Provinces of La Rioja and Soria (Pascual & García 2001-2002, 2003a-d) and J. Sánchez on the Balearic Island of Menorca (2001, 2005, 2006) are the veritable pioneers in this field in Spain. Articles summarising their work appeared recently in the proceedings of the Rome colloquium (Pascual & García 2011; Sánchez 2011), organised by D. Williams and D. Peacock.

P. Pascual and P. García, recently allied with J. Castro, have also identified millstone quarries in the Basque country, whereas J. Sánchez recently began surveying the neighbouring island of Majorca. Most of these finds are recorded in the atlas of millstone quarries (eu.millstonequarries) available on the Internet (http://meuliere.ish-lyon.cnrs.fr).

For Iron Age millstone procurement, there are two articles that delve, although only briefly, into the question of the source of millstones. The first is that of Checa *et al*. (1999) on the querns of *Numantia* (Soria). The second is the work of the team led by N. Alonso (2011) on the mills of the settlement of Els Vilars (Catalonia). For more recent periods in Catalonia, M. Sancho (2008) has briefly noted the quarry of Vilamolar (Lleida) in her study of the exploitation of natural resources in Medieval times, and A. Gutiérrez (2009), in her study of ancient building block quarries, has alluded to the millstone production at the Montjuïc of Barcelona. This last site is by far the most celebrated millstone quarry on the Iberian Peninsula (fig. 1.4-5).

Far from the Spanish mainland, but not devoid of Interest, is the work by the team of A. Rodríguez on the volcanic quern quarries of the precolonial Guanche inhabitants of the Tenerife Island in the Canary Islands who extracted rotary querns from bedrock with stone tools.

Fig. 1.4: Photograph from c. 1915 of the sandstone quarry of Montjuïc (Barcelona) with an arrangement of millstones (and other products, notably conical oil rollers) in the form of monoliths and segments. The scene, although certainly staged, shows the predominance of the pick as a cutting tool (from the blog of Ana María Ferrin, http://amf2010blog.blogspot.com.es/2012/03/gaudi-y-la-piedra-un-magico-acuerdo.html).

Fig. 1.5: Undated photograph of the Montjuïc quarry. To the right, in the foreground, is a half-fashioned millstone. A second millstone can be seen in the background to the left of the compressor. Source unknown.

One of the more complete works dedicated specifically to the millstone industry is the monograph by J. Maestro Hernández (2011), based in part on field work, Historical archives and Interviews with the descendants of the millstone makers from the mountains of Palencia.

In our study area, the following articles stand out: Matilla (2001) on the oil roller and millstone quarry of Fortuna (MU-4) in the autonomy of Murcia; Montero (2008) on the spectacular *rosso ammonitico* quarry of Los Frailes near Cabra (CO-1) in Córdoba; Martínez and Granero (2005) and its revised version (Martínez *et al.* 2011) on a conglomerate quarry near Albox (AL-3) (Almería); Altamirano and Antón (2012) on the Patriarca site (CO-12) on the outskirts of the city of Córdoba; and Molina and Cultrone (2012) on the provenance of the millstones from archaeological contexts in Baza (Granada). All, said, none of this research goes beyond the domain of the case study.

Indirectly related to millstone quarries are a number of quern and millstone studies that will be cited throughout this work. Those that stand out are the following: Borges 1978; Py 1992; Checa *et al.* 1999; Alonso 1999; Asensio *et al.* 2001; and Berrocal Rángel 2007. This last study is the most extensive typological work at the national level, based on an unfinished catalogue of 406 millstones compiled in the 1940s by the director of the National Museum of Archaeology of Madrid, Augusto Fernández de Avilés.

The backbone of this study, nonetheless, is the research that I have undertaken since 2007. The research includes data from a series of unpublished reports I have penned based on the observation of millstones stored in provincial and municipal museum depositories such as Priego de Córdoba and Almedinilla (Córdoba); Baelo Claudia (Cádiz); Vélez Rubio and Almería (Almería); Málaga (Málaga); Baza (Granada); Murcia; and Linares, Úbeda and Alcalá la Real (Jaén), and Mérida (Extremadura).

Along with the Internal reports, I have published several papers on the subject of Iberian millstone quarries from Protohistory to the Middle Ages. The first paper appeared in the proceedings of the conference of Saint Julien sur Garonne in France (Anderson 2011). This was followed by two articles in the proceedings of the Rome colloquium, the first being a collaboration with the geologists T. Grenne of the Norwegian Geological Survey and J. M. Fernández Soler of the University of Granada, on the subject of quern and millstone production in Antiquity in the volcanic provinces of the Cabo de Gata (Almería) and Campo de Calatrava (Ciudad Real) (Anderson *et al.* 2011). The second was a general review of millstone quarries in southern Spain, a collaboration with the geologist J. Scarrow of the University of Granada, with emphasis on the Modern and Contemporary productions identified through the Internet and consultation of old texts. Two other articles are currently pending publication. The first, submitted to the proceedings of the conference held in 2011 in Lons-le-Saunier, France, is a collaboration with the archaeologist L. Jaccottey (INRAP, France) and the geologists J. Scarrow and A. Cambeses of the University of Granada, examining the question of Pompeian mills in the Iberian Peninsula. The second, a diachronic study of rotary querns and their quarries in southern Spain, in collaboration with J. Scarrow and A. Cambeses, has recently been submitted to the proceedings of the colloquium held in Bergen, Norway held toward the end of 2011.

This work also benefits from unpublished data stemming from my participation in the excavation of three quarries in France at Claix (Charente) and Mont Vouan (Haute-Savoie) under the direction of A. Belmont (University of Grenoble, LARHRA), as well as the study, in collaboration with A. Hauken Dahlin, of the ancient rotary querns of the Museum of Stavanger. This last project, a monograph still to be published, was undertaken the framework of the Norwegian Millstone Landscapes research project (directed by G. Meyer, T. Heldal and T. Grenne).

1.4. Terminology: querns, millstones and quarries

The term "millstone" in this study, depending on the context, is used in both its broad and narrow sense. "Millstone" in its broad sense includes any type of grinding stone, from the early slab or quern from the Neolithic, driven with a to-and-fro motion, to rotary hand mill (quern), to the large heavy millstones driven by watermills. In its more narrow sense "millstone" refers to the larger millstones of watermills. The equivalent terms in Spanish (*muela*) and French (*meule*) also refer to all types of stones, from Neolithic to Contemporary times. All of these terms are at times ambiguous, leaving one wondering if the reference applies to a handmill or to a more sophisticated mill. The English language, benefits nonetheless from the term "quern" to specify the smaller hand driven mill. Thus, in this work, the term "quern" is exclusively used to designate the smaller handmills and "millstone" is usually reserved for the larger mechanisms with more complex driving mechanisms such as man or animal-driven mills, watermills and windmills and "quern" will refer to small, hand-driven mills.

The term "quarry" is defined simply as a place where stone is extracted. In English, the term "quarry" applied to millstone extraction is, in a certain sense, a misnomer. According to the *Oxford English Dictionary*, the word has an origin in Middle English, a variant of medieval Latin *quareria*, from the Old French *quarriere,* based on Latin *quadrum* "a square", a shape far from that of a circular millstone. In spite of the irony of the origin of the term, it is adopted in its general sense as a place where millstones are extracted. The Spanish and French languages, contrary to English, benefit from specific terms to designate millstone quarries (*molera* and *meulière)*.

For our purposes, the term "quarry" is stretched in the sense that it not only is the place where stone is extracted directly from bedrock by cutting or by detachment, but also specifies natural features such talus or scree at the base of a slope or a river beds or ravines where rocks were repeatedly gathered for millstones.

Concerning the personnel related to millstone quarries, in Spanish and French, contrary to English, there are specific terms (*molero* and *meulier)* to designate the mill maker. One of the rare images of *moleros* "at work" in Spain is that of the of the quarry of Brañosera in the mountains of Palencia (fig. 1.6). In Spanish the term *molero* is also synonymous to a mill merchant.

*Fig. 1.6: Photograph dating to March 1933 of millstone makers (*moleros*) at the quarry of Brañosera in the mountains of Palencia (from Cuevas Ruiz 2006).*

1.5. Chronological framework

Due to the embryonic state of research on both millstone quarries and millstones themselves, the quarries can only be placed, at best, in broad chronological niches. A large group of sites defy a chronological classification and can fall into any of various periods. For our study we have adopted the traditional dating system used for southern Spain.

The oldest quarries date from the Late Neolithic, towards 3000 BC. These saddle quern sites are incidental to our study and are presented because they are, presumably, also sources of later Roman querns. The third early site dates from the transition of the Chalcolithic and the Bronze Age, roughly from 2000 and 1500 BC. The sole millstone source from the Late Iron Age correspond to a mid-2nd century BC site in the Iberian Culture "hInterland". This is followed by a series Roman sites spanning several centuries from the 2nd century BC until about the 4th-5th century AD. The transition from Late Antiquity to the Early Middle Ages, marked by the Germanic domination, is hazy and some productions attributed to the Roman period might actually be from the 6th and 7th centuries. In spite of the major political and social changes that took place with the onset of the Islamic domination in 711, this long part of in the Middle Ages is particularly poorly certified for millstone production. The expulsion of the last Islamic ruler from Granada in 1492 marks the end of the Middle Ages. The Reconquest, however, was a long process which explains the series of historical documents in Castilian that predate 1492. The few centuries of the Modern period sees a slight increase in quarries documented by written sources. It is the arrival of the Contemporary period in 1789, based on the French Revolution, that marks the highest production of millstones. These are often recorded in dictionaries of the first half of the 18th century. Beyond the 20th century there are very few records of quarries.

1.6. The problems of identifying millstone quarries

Differentiating quarries that produce millstones for grains from other quarries with cylindrical extractions (i.e. column drums, oil rollers, sharpening stones) is not necessarily a simple task. Roughouts, extraction hollows and tool marks of all of these types of products are identical.

The quarry of Cerro Bellido (see catalogue, SE-4) in the Province of Seville is an example. The site is reputed to be a Roman exploitation of column drums (fig. 1.7). The rock is a coarse and porous limestone, similar to rocks often chosen for millstones. The parallel diagonal lines left after extraction on the quarry faces are identical to those seen in millstone quarries. The main difference is that the drum roughouts, although of a diameter (1,00 m) like many millstones, are proportionally thicker than millstone blanks.

In this particular case, abandoned millstones found in the nearby riverbed of the Yeguas River, has led local historians to speculate that unused drums at the Cerro Cerrido were recycled in Medieval times as millstones (F. Estepa, pers. comm.).

Fig. 1.7: View of the Roman column drum quarry of the Cerro Bellido (SE-4, Casariche, Seville) and detail of an abandoned drum. It is reported that drums from this quarry were reused as millstones in Medieval times.

The last generation of olive crushers for *almazaras* (oil mills), often seen decorating public places throughout southern Spain, are large granite cones, usually more than 1 m of diameter at their base. Due of their conical shape, there is no possible confusion with cylindrical millstones. There are, however, older oil rollers, for example at the 15th-century mill of Nigüelas (Granada), equipped with upright cylindrical or slightly trunco-conical rollers (fig. 1.8). Depending on the type of rock and their shape, the *almazara* roller quarries, of which at least a dozen are identified in our study area in the dictionary of P. Madoz (1845-50), could be difficult to distinguish from grain millstone quarries.

Quarries of cylindrical sharpening stones, a common tool as seen in a painting by Goya (fig. 1.9), are also difficult to distinguish from cereal millstone quarries. From old geographical texts we deduce that these *amoladeras* exploitations were plentiful. The most famous in our study area, cited in ancient texts, are the reddish sandstones around Alhambra (Ciudad Real) (Benítez de Lugo 2001: 13). Montoro (Córdoba) is also reputed for its sharpening stones made from a fine reddish *Bundsandstein* (*piedra molinaza*) (Clementson 2012: 3-5). However, through historical archives, we know that reddish millstones for grain grinding were also scored at Montoro (CO-14) (Córdoba de la Llave1988: 843, footnote 22).

Finally, other industries such as the 19th century sugarcane industry along the Granada coastline, also needed millstones. The shell-rich *ostionera* cane crushers on display in the Castle of Almuñecar (fig. 1.10) were certainly imported from quarries in the Cádiz area. These medium-sized cylinders could easily be confused with medieval millstones.

Differentiating extractive hollows from features totally unrelated to millstone production is also a problem. Circular extractions have been Interpreted as brine evaporation cavities for salt production, animal drinking troughs, prehistoric sun symbols or marks to delimit the boundaries of property (fig. 1.11).

Finally, identifying sites devoid of extractions hollows, where angular blocks were scored for composite millstones, banded together with plaster and fastened by iron bands, leaves little evidence in the field that permits them to be identified with millstone quarries.

Fig. 1.8: Reconstruction of a Moorish donkey-driven olive oil mill dating to the 15th century (Nigüelas, Granada). Outside of its context, the vertical olive roller could easily be confused with cereal millstone (photograph by Eve Andersson).

Fig. 1.9: Rotary sharpening stone (1808-1812). Painting by Francisco de Goya. Exposed in the Budapest Museum of Fine Arts. The stone appears to be a fine-grained, rose sandstone.

Fig. 1.10: Millstones of shell-rich ostionera *stone on display at the Castle of San Miguel of Almuñecar (Granada). These medium-sized stones (65 cm in diameter) are reputed to have been used in the recent sugar cane industry.*

Fig. 1.11: Example of the difficulty of Interpreting extraction sites. Abandoned granite quern extraction or property boundary near Ávila (Ávila) (from the blog of M. Serna Martínez; http://terraeantiqvae.com/profiles/blogs/el-medievo-a-las-puertas-de-vila#.UV0wl45FfuE).

1.7. Linguistic questions

In this work, we have resorted to the use of English names for well-known localities in Spain. For example, to designate the Spanish autonomous community of *Andalucía* or its capital *Sevilla*, we employ the terms "Andalusia" and "Seville." Most locations, however, do not have English counterparts so the original Spanish name, including accents, is used.

Spanish personal names consist of both patronymic and matronymic names received at birth. There are a number of cases of authors who have the same name. In these cases, so as to avoid confusion, both the patronymic and matronymic are noted.

2. SOURCES, RESOURCES AND FIELDWORK

Conventional sources, in particular, historical archives, old geographical dictionaries and molinological studies, have been essential and provided the bulk to establishing the inventory of 138 millstone quarries or millstone quarry districts that appear in the catalogue of this study. Newer, unconventional sources, for the most part historical accounts or hiking itineraries on the Internet, represent about a third of the sites. A series of tools related to cartography, geology, toponymy, available over the Internet, have also been extremely useful.

At times, sites are identified in more than one source. Unfortunately, most of the information collected from both conventional and unconventional sources is extremely perfunctory. Most of the quarries are only mentioned in passing - rare are the texts that offer more than a few lines describing the site. Even scarcer are those with illustrations and descriptions of the rock type. The following is a detailed description of the different sources.

2.1. Sources

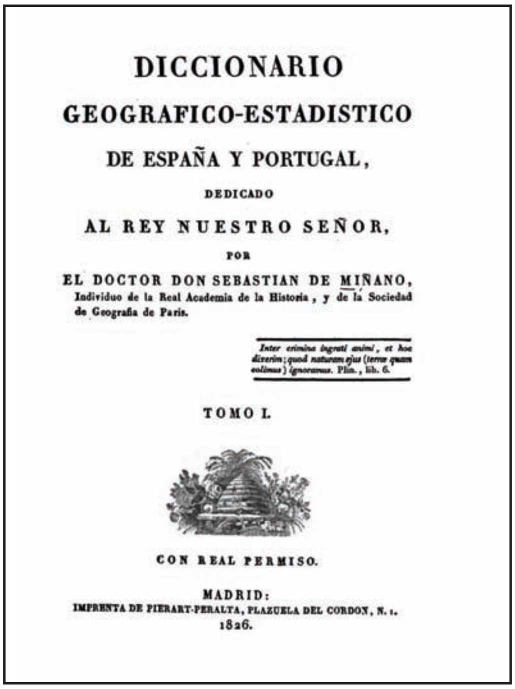
2.1.1. Conventional sources

2.1.1.1. Old geographical dictionaries and other chronicles (59 sites)

The geographical dictionary compiled by P. Madoz (*Diccionario geográfico-estadístico-Histórico de España y sus posesiones de Ultramar*, in 16 volumes (1845-1850) (fig. 2.1a), is by far the most valuable source for identifying millstone quarries. Of the 138 sites presented in this work, 43 come from Madoz. The earlier, less complete, dictionary of S. Miñano (1826-1829) accounts for about a half dozen sites in our study area (fig. 2.1b). The series *Crónica General de España*, organised by Province (Granada, Málaga, Cádiz, etc.), published two decades after Madoz' work, brings to light some sites not recorded by either Miñano or Madoz. Other travel narratives (i.e. Cruz y Bahamonde 1813), local histories (i.e. Martínez y Delgado 1875) and Exposition Catalogues (Paris Exposition 1867) also provide information about quarries. The drawback of all these sources is that they rarely offer more than the basic information about a quarry.


DICCIONARIO
GEOGRAFICO-ESTADISTICO-HISTORICO
DE
ESPAÑA
Y SUS POSESIONES DE ULTRAMAR.
POR PASCUAL MADOZ

MADRID.
1845-1850


DICCIONARIO
GEOGRAFICO-ESTADISTICO
DE ESPAÑA Y PORTUGAL,
DEDICADO
AL REY NUESTRO SEÑOR,
POR
EL DOCTOR DON SEBASTIAN DE MIÑANO,
Individuo de la Real Academia de la Historia, y de la Sociedad de Geografía de Paris.

Inter crimina ingrati animi, et hoc duxerim; quod naturam ejus (terrae quam colimus) ignoramus. Plin., lib. 6.

TOMO I.

CON REAL PERMISO.

MADRID:
IMPRENTA DE PIERART-PERALTA, PLAZUELA DEL CORDON, N. 1.
1826.

Fig. 2.1: Cover pages of the geographical and historical dictionaries known as "the Madoz" and "the Miñano": a) Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar, 16 vol., 1845-1850; b) Diccionario Geográfico y Estadístico de España y Portugal, 11 vol., 1826-1829.

2.1.1.2. Historical archives and censuses (19 sites)

A series of old documents, in particular old ordinances and commercial transactions, coming from historical archives as well as old censuses are a vital source of information especially for the time span between the end of the Islamic domination and the 19th century when the information is provided for the most part by geographers. They not only identify about 20 millstone quarries, but throw light on a series of question related to ownership and commerce.

A series of Medieval codices, codes, ordinances and other legal documents stored in national, provincial and municipal archives reveal Interesting data millstone quarries, in particular from the Middle Ages during struggle between the Islamic and Castilian domination (Table 1). The early *Fueros* (Legal Codes) of Sepúlveda (Segovia) (1076) Cuenca (1190) and Béjar (Salamanca) (end 13th, beginning 14th centuries) provide directives about the ownership and conditions of lease of millstone quarries. A legal dispute over millstone extraction in 1501 between citizens of Málaga and citizens from Antequera (Málaga) even reached the court of the Catholic monarchs Ferdinand and Isabel in Granada. A municipal ordinance in Loja (Granada) in 1502, delivered by the *Pregonero* (town crier), warned of the consequences of not declaring millstone extraction. A similar ordinance in 1566 in Llerena (Extremadura) warns "foreigners" or "outsiders" of the consequences of extracting millstones without official authorisation.

Notarial protocols, another type of historical document, record commercial agreements and, at times, cite the location of quarries and throw light on when they were exploited. This is the case of the sites of Santa Ana de Albaida (CO-7), Hornachuelos (CO-13), Montoro (CO-14) (Córdoba) cited in protocols dating to 1481 and 1486. The sites of Iscar (CO-5) and Molino

Table 1: List of millstone quarries cited in national, provincial and municipal archives.

Site code	Site	Year	Archive Location	Archive reference number	Bibliography
CO-07	Albadia	1486	Córdoba	1486.04.02, AHPC, PNCo, 14-21, 1, 44r	Córdoba de la Llave 2003:306
CO-13	Hornachuelos	1481	Córdoba	1481.02.18, AHPC, PNCo, 14-17,3, 73r	Córdoba de la Llave 2003:306
J-8	Villargorda	1499	Jaén	1499.11.26, AHPJ, PNJa, 9, 415r	Córdoba de la Llave 2003:306
MA-1	Torcal (?)	1501	Granada	A.G.S. R.G.5., XII-1500 [sic, date 1501]	Fernández 1982
GR-2	Loja	1502	Loja	AML, Leg. 49, p. 9. 1 cuartilla + 1.	Municipality of Loja
CO-10	Bélmez	1606	Pozoblanco	not specified	González Peralbo blog (see cat.)
CO-10	Bélmez	1616	Pozoblanco	not specified	González Peralbo blog (see cat.)
CO-6	Iscar	1557	Córdoba	1557.01.30, AHPC, PNBa, 4P, 70v	Córdoba de la Llave & Varela 2011: 106
CO-14	Montoro	1481	Córdoba	1481.26, APC, 14-5, 3, 38 r.	Córdoba de la Llave 1988
CA-3	Rota	1719	Madrid	A. H. N., Nobleza, Osuna, libro 19, p. 104.	Martínez, J. A. (pers. comm.)
CA-3	Rota	1745	-	not specified	Martínez, J. A. (pers. comm.)
TO-2	Ventas con Peña Aguilera	1587	Madrid	A. H. N., Nobleza, Frias, leg. 313/2 a	Baltanas 1998: 35-36

de la Piedra (CO-6) in the Municipality of Baena (Córdoba) are likewise cited in documents from 1557. Knowledge of the *molero* of the Juan de Bargas and the quarry of Bélmez (CO-10) (Córdoba) comes from contracts dating to 1600 and 1616.

Several censuses, in the form of questionnaires, compiling data about the geography, demography, production, natural resources and commerce of Spain, furnish information about a half dozen millstone production sites. The oldest, known as the *Relaciones topográficas de los pueblos de España* (1574-1578), ordered by King Philip II, consisted of 24 queries. This census accounts for the sites of Ventas con Peñas Aguilar (TO-2) (Toledo) and Montarrón (GUA-8) (Guadalajara). A second major work, two centuries later, is known as the *Catastro del Marqués de Ensenada* (1750-54). The 40 questions of this survey were answered by representatives of about 15,000 locations throughout Spain. Curiously, although this work mentions and illustrates watermills throughout the Spanish landscape (fig. 2.2), it only accounts for two millstone quarries, Fuentealbilla (AB-1) in Albacete and El Berrueco (CA-8) in Cádiz. A third census was undertaken exclusively in Extremadura (*Interrogatorio de la Real Audiencia de Extremadura de 1791*) and accounts for the sites of Alconera (B-1), Llerena (B-2) and Llera (B-3). Finally, the geographical and historical dictionary of Tomás López de Vargas Machuca from the late 18th century, a project that remained unpublished, provides data about a few sites, notably Colmenar de Oreja (Madrid), (M-2), Sierra de Utrera (Ma-8) by Casares (Málaga) and Otívar (GR-13) (Granada).

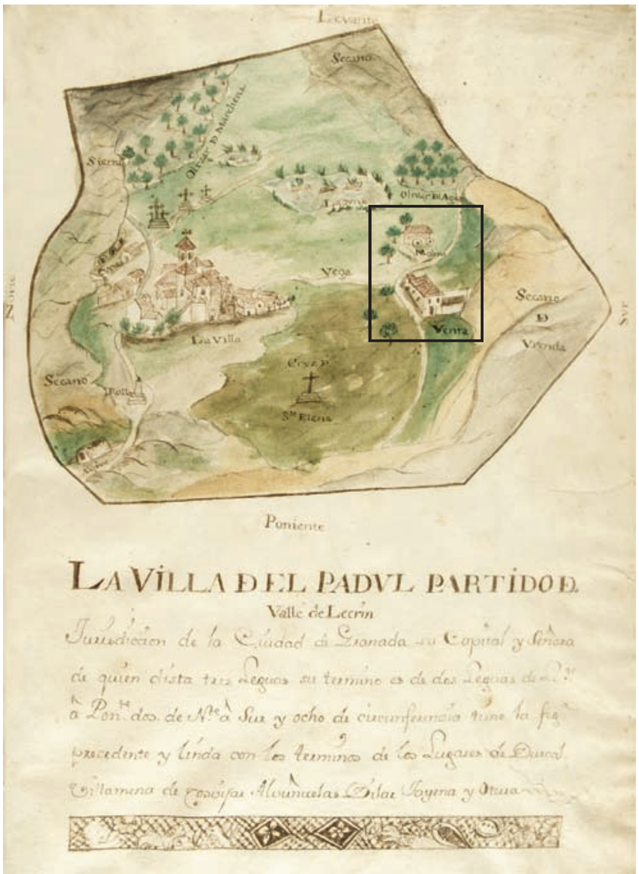


Fig. 2.2: Extract and detail of the Padul (Granada) entry to the Census of the Marqués de Ensenada. The watermill is set along the irrigation canal. Although almost every town sketch shows at least one mill, millstone exploitations, despite sometimes being cited in the responses to the queries, are never illustrated (from El Catastro del Marqués de Ensenada en el Antiguo Reino de Granada, Instrumentos de Descripción, Archivos 16, A.H.P.G, CD, no date).

2.1.1.3. Molinological studies (28 sites)

In the last decades, in southern Spain, there has been growing Interest in the question of ancient mills, especially watermills. The organisation ACEM (*Asociación para la Conservación y Estudio de los Molinos*), for example, is active conserving and studying these sites and has organised conferences every two to three years. Two of the few articles specifically related to the subject of millstone quarries (Rambla Honda: Martínez & Granero 2005; Cabra: Montoro 2008) were published in the proceedings of these conferences. Other molinological studies in the form of monographs, such as that of Gómez (2003) on the watermills of the Odiel River of Huelva, Cara Barronuevo *et al.* (1999), on the mills of the Alpujarra mountains of Almería, and Córdoba de la Llave & Varela (2011) on the mills of the Guadalquivir River Valley, as well as extended articles, such as that of Córdoba de la Llave (1988, 2003) on medieval watermills in Córdoba, provide valuable information about millstone exploitations. An article by Baltanás (1998), related to the renovation of a 16th-century watermill in Colmenar de Orejo (Madrid), indicates in passing, for example, that the new millstones were acquired from Ventas con Peña Aguilera (Toledo), a granite exploitation about 100 km away.

2.1.1.4. Historical and archaeological research (14 sites)

Other historical and archaeological research unrelated to molinology has also provided direct or indirect information about millstone production. Quern production is identified at the volcanic outcrop of Cancarix (Albacete) in a study of Roman settlements on the Minateda-Agramón region (Jordan *et al.* 1983). Recent excavations of the settlements in the Municipality of Pinos Puente (Granada) (Anderson 2010, unpublished) and Cerro de la Cruz (CO-15) (Almedinilla, Córdoba) (Quesada *et al.* 2010) have indirectly provided information about potentioal local sources of millstones. Archaeological surveys such as that of the Sierra Molar (Alicante) (Gutiérrez *et al*. 1998-1999) and provincial site inventories (Almonaster la Real, Huelva; Mazarrón, Murcia; Los Molares, Córdoba) also provide valuable information as to the existence of millstone quarries.

2.1.1.5. Millstones in museum depositories

Petrographic analyses of querns and millstones in museums can also yield Interesting clues as to the presence of local or regional quarries. The large assemblage in the Museo National de Arte Romana in Mérida (Extremadura), for example, dominated by granitoids, certainly reflects work in local and regional granite outcrops. In similar fashion, the biocalcarenite querns in the collections of *Baelo Claudia* (Cádiz) and volcanic rocks (notably lamproites) in Murcia point to local and regional millstone productions.

The presence of a group of quern roughouts in depositories, such as those from Mazarrón in the museum of Murcia or the group on display at the archaeological sites of Oreto y Zuqueca in Ciudad Real, are artefact that usually do not travel long distances from their source and most likely indicate a nearby quarry.

2.1.1.6. Geological articles and itineraries (6 sites)

Several sites are identified in both old and new geological studies, as well as geological itineraries. Quarry production is cited, for example, in geological articles concerning the sites of Berrueco (M-1) (Madrid); Sierra Utrera (Ma-8) (Málaga); Linares (J-7) (Jaén); Arenales, Trassierra (CO-9) (Córdoba); Pinilla de Jadraque (GU-2) (Guadajara) and Cobeta (GU-9) (Guadajara).

2.1.1.7. Toponyms

Toponymic literature has not resulted in the identification of any millstone quarry. However, the place name search engine for Andalusia available on the Internet (*Buscador de nombres geográfico, Junta de Andalucia*: http://www.ideandalucia.es/nomenclator/) has helped identify the location of several quarries and has identified a series of potential production sites that have yet to be confirmed. This branch of study has been of great assistance, however, in Interpreting the nature of sites identified by other means. The most significant site identified through this research is that of *Piedras molares* near Villanueva de Córdoba. This name literally means "*millstone stones*". S. Gutiérrez of the Historical Museum of Villanueva de Córdoba has confirmed the existence of granite extraction at the site, but millstone production is still to be confirmed.

2.1.1.8. Personal communications (11)

Personal communication has been essential in identifying a series of sites. This applies to pinpointing sites in the field indicated by other written sources. For example, Á. Serrano of Loja, Granada, a former miller and son and grandson of millers, led me to the sites Loja (GR-2/3). A series of other sites (e.g. Alhama de Granada (GR-6), Los Guillares (GR7), etc.) would never have been located in the field without the help from the local Tourist Information Office or from Municipal Officers contacted by telephone. Personal communication was particularly important for sites that were never, to our knowledge, recorded in a written source. The quarries of La Merced (GR-4a/b/c) were communicated to me by the historian J. Ortis of Algarinejo. The Roman quarry of Cerro de Limones (AL-1) and the coastal site of Calahonda (GR-9) were communicated respectively by the geographer L. Martínez and the archaeologist I. Torres, Director of the Archaeological Museum of Granada.

2.1.2. Unconventional sources

2.1.2.1. Local history reports posted on the Internet (20 sites)

The new Internet technology has opened up the doors to a large number of local historians and amateurs to disseminate, by means of blogs and other web sites, local information that otherwise would remain silent. Although this type of information must be considered with caution, it is an invaluable source to identify millstone quarries, especially when the web site is accompanied by photographs. About two dozen sites can be attributed to this type of source, notably the sites of Rota (CA-3/4/5), Ubrique and Benaocaz (CA-11/12) (Cádiz), Plasencia (CC-1) (Cáceres) and Guijo de Galisteo (CC-5)

Establishing contact with the authors of some of these historical reports also has been extremely beneficial. The contact with P. Arjona and J. A. Martínez of Rota, M. Domínguez of Plasencia (Extremadura), A. Alonso (Huelva), J. Ortíz (Zagra and Loja), has led to the collection of further Interesting personal communication, as well as photographic and archival records of quarries in their localities.

Some quarries, initially identified by unconventional sources, are ultimately confirmed in conventional sources. One of the more notable exceptions is the spectacular Guillares (GR-7) (Granada) quarry , recorded to our knowledge only in the web site of the Municipality of Padul.

2.1.2.2. Travel itineraries on the Internet (11)

About a dozen quarries have been identified through hiking or biking itineraries. The presence of these exploitations along these itineraries is probably not a coincidence. These modern tourist routes probably coincide with the old paths and roads, the same that were trudged in past times by millstone transporters. Some sites, such as Soneja (CS-1) (Castellón) and El Láchar (J-2) (Jaén), benefit from explanatory panels. The site of El Torcal (MA-1) (Málaga) is along a secondary path in the protected karstic national reserve. Probably the most unique site identified by this means is the site of Isla de la Paloma (CA-7) (Cádiz), cited in a scuba diving itinerary.

2.1.2.3. Photographs, videos and postcards on the Internet (3)

Photographic stills and videos posted on the Internet are also a new, unconventional means of identifying these sites. Photographs account for the identification, for example, of Guijo de Galistea (CC-5) (Cáceres) and Albardado, Bélmez (CO-10). Almaden de la Plata (SE-1) (Seville), Zagra (GR-5) (Granada) and Granátula de Calatrava (CR-5) (Ciudad Real) came to our knowledge by videos on the YouTube.

Old photographs or postcards available on the Internet, offer valuable insight into the old quarry work, products and transport at Gerena (SE-7) (Seville) or Colmenar Viejo (M-3) (Madrid).

2.2. Resources: cartography, geology and toponymy

The resources that figure heavily in this study, applied both as a means of identifying sites and their study after identification, are the following:

SIGPAC: Sistema de Información Geográfica de parcelas agrícolas. This online service provides topographical information, general data about place names, and orthophotos (http://sigpac.mapa.es/fega/visor/).

SEC: Sede Electrónica del Catastro (https://www1.sedecatastro.gob.es/OVCInicio.aspx). This online service provides detailed names of the different parcels of land that at times reveal a toponym that could be related to millstone production.

Other online maps such as Google Earth, Google Satellite view and Google Street view have equally been consulted.

IGME: Mapa Geológico de España. This online service provides geological maps at the scale of 1:50,000, as well as an explanatory booklet (http://www.igme.es/Internet/cartografia/cartografia/magna50.asp).

Nomenclátor Geográfico de Andalucía. This online service provides a database of place names for Andalusia (http://www.ideandalucia.es/nomenclator/).

RAE dictionary: *Diccionario de la Lengua Española, Real Academia Española*, Edition 22 (http://lema.rae.es/drae/).

2.3. Fieldwork

2.3.1. Identifying sites in the field

Field surveys of millstone quarries are essential to this study. Although written sources, for example, are important for identifying and dating, it is the physical examination of a quarry that provides the most data on extraction techniques, extraction dimension, rock type, and other potentially related features, such as roads and dwellings. Field work also offers the possibility to determine other phases of production that are not mentioned in written sources.

Of the total 138 sites identified through old texts, the Internet, etc., about a third (48) were visited in the field. Most of the work was done alone or in company by previously arranged or spontaneously organised local guides. In a few cases, I benefited from the company of geologists of the Norwegian Geological Survey or the University of Granada. Visits to 6 sites, after a long planned trip, were unsuccessful because they were either not accessible (fenced off on private property, in active hunting grounds, protected by dangerous animals) or simply not found. Only a few, such as Los Guillares (GR-7) or Moclín (GR-1), were visited more than once.

Because of the lack of time and the long distances, the visits consisted, for the most part, of brief, superficial inspections. No proper systematic topographical survey, scaled drawing, much less a proper modern excavation, was possible to undertake. The data collected at the site consisted of general descriptions, counting and describing extraction hollows and collecting rock samples. Because of our previous experience with the excavation of Châbles in Switzerland (Anderson *et al.* 2003), we were particularly sensitive to the possibility of the presence of related features such as means of access (roads, paths), smithy features and dwellings. On account of the limited amount of time spent at each site, an emphasis was placed on photographing as much as possible to establish a record for further study in the office.

Most of the millstone quarries in our study area have been relatively easy to access, in particular those on or near the coastline, such as Carchuna (GR-9), Trafalgar (CA-1) (fig. 2.3), Guardias Viejas (AL-4) (fig. 2.4) or Hoya del Paraíso (AL-2). Other sites such as Zagra (GR-5) or La Merced (GR-4) are on or beside roads and can be attained directly by a vehicle. The sites such as Moclín

Fig. 2.3: View of the easily accessible quern quarry on the coast of the Bay of Trafalgar (Cádiz).

Fig. 2.4: View of the easily accessible millstone quarry of Guardias Viejas (Almería).

Fig. 2.5: View from the southwest of the Cerro Limones Volcanic mountain. Access to the quern quarry, located at the top of the mountain, is moderately difficult.

Fig. 2.6: View of the millstone quarry of Castillo de Locubín (Jaén). Access to the site on a steep slope was moderately difficult.

(GR-1) or Plasencia (CC-1) are in or near towns. Some, however, are in less accessible mountain terrain and moderately difficult to attain. The Cerro de Limones (AL-1), for example, required an hour's hike up a mountain (fig. 2.5), whereas Castillo de Locubín (J-1) (fig. 2.6) was on a steep, slippery slope.

Sources on the whole, in particular written texts, do not provide detailed information on the whereabouts of the sites, complicating their identification. The old written information can also be misleading and lead to hours and hours of walking. The reference of Madoz to Alcalá la Real (Jaén) (Madoz, Vol. 1: 382) includes both a place name (*Las Canteras*) and the name of the mountain *Acamuña* (today *Camuña*), data that helped narrow down its location. The problem, and what complicated our search, is that it is not in Alcalá la Real but, in fact, just on the other side of the border of the neighbouring Municipality of Castillón de Locubín.

At times, the information is limited only to the name of the municipality. Finding these sites is therefore like searching for a needle in a haystack. For example, it was impossible to find the Otívar quarry (GR-13) in 57 km2 of rough, mountainous terrain. For this reason, a survey of the sites only identified by their municipality, including Vera (AL-9) (Almería), 58 km2; Linares (J-7) (Jaén), 197 km2; Zalamea la Real (HU-6) (Huelva), 238 km2; Chillon (CR-3) (Ciudad Real), 208 km2, was not attempted. These have, nonetheless, been retained in the general catalogue, and we retain the hope to someday they will be identified.

Quarries even more difficult to pinpoint are those described only at the level of the Judicial District. Madoz (1847: Vol. 9, 42) mentions workings in the *Partido Judicial* of Guadix (Granada), an area of 9 by 7 leagues, equivalent to about 1500 km2). The same applies to the "spongy" *toba* rock quarry (or quarries) used for flour millstones somewhere in the Judicial District of Zafra (Extremadura) (Madoz 1850, Vol.16: 443) in an area of about 6 x 3 leagues (c. 600 km2) and the "new, little known" millstone quarry in the Judicial District of Nules (Castellón) (Madoz 1849: Vol. 12, 195) also a vast area.

In any case, without the assistance of local information and guides, many sites would never have been visited in the field. The names of each of the people that have assisted to find these sites are noted in the individual entries of the site catalogue.

2.3.2. The state of conservation of sites

The state of conservation of millstone quarries in our study area is variable. Some, due to subsequent rock exploitation, are no longer recognisable as millstone quarries. This is the case of sites of El Berrueco (CA-8) and La Pila (CA-9) in Cádiz, or Sierra del Molar (A-1) in Alicante where vast modern exploitations for construction material continued until recent times and have probably obliterated all the old extraction features.

Other sites have clearly been ransacked by pillagers. At the Cerro de Limones there are several groupings of the better conserved querns in preparation to be taken away (fig. 2.7a). In fact, many blanks and roughouts from the Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2) (Níjar) are now decorating the nearby towns of Presillas Bajas and Rodalquilar (fig. 2.7c-d). Pillaging is not limited to the smaller querns. Local residents informed me that the better conserved abandoned millstones of Lora de Estepa (SE-2) also now decorate private gardens.

Often these sites, even if not all that old, are heavily weathered and the tool marks have been eroded. The case of Castillo de Locubín (J-1) is a good example. The rock exposed to weathering contrasts highly to that of the protected rock (fig. 2.8).

Fig. 2.7: Example of the pillaging of a millstone quarry. The pillaging of sites in the volcanic district of the Cabo de Gata (Almería) is a severe problem for the future of millstone quarry research. It is, however, due to this pillaging that we have learned of the existence of certain sites.

2.3.3. Equating written sources with field finds

The question arises if a site identified in the field can be securely equated with a site described in an old written source. When the information from the text is explicit and offers a place name or other topographical data, then we can be confident that the site in the field is the same as that of the text. At times, however, when there is little or no written information about the site's whereabouts, there is the possibility that the site identified in the field is not the same as that of the text. For the needs of this study, however, we are compelled to part with the assumption that finds in the field correspond to the written records.

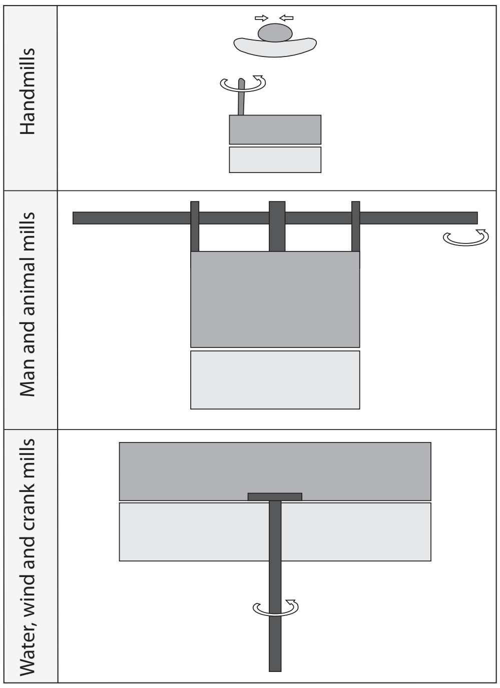
Fig. 2.8: Views of two abandoned millstones at the quarry of Castillo de Locubín (J-1). The cylinder to the left is exposed to weathering agents and covered with moss, whereas the example on the right, near the base of a rock cliff, is protected from weathering and reveals the original colour of the stone.

3. MILLSTONE QUARRY PRODUCTS AND MILLING INSTALLATIONS

3.1. Introduction

Before examining the millstone quarries themselves, we will briefly review the wide variety of millstones produced in these quarries, from the earliest prehistoric saddle querns to the large millstones that equipped mills still used in the 20th century. In the centuries that have transpired since the earliest to-and-fro driven querns, a number of factors, including the introduction of rotary motion and the invention of special means of assembling and centring millstones (spindle, rynd and other fittings), as well complex means of traction (gearing), have had an profound effect on milling technology, resulting in a wide variety of mills driven by either man, animal, water or wind (fig. 3.1). These changes in technology are also reflected, to a certain extent, in the techniques of extraction and the choice of rocks.

In our study area, with the introduction of the rotary motion in the Iron Age, appear simultaneously the rotary hand-quern and the first larger rotary man-driven mills. Later version of the larger mills, in Roman times, will take on the form of Pompeian and cylindrical mills that will continue to evolve until Contemporary times in the form of *tahonas* (animal-driven mills).



As to the watermill, in spite of growing evidence of it introduction elsewhere in Roman times, there is practically no evidence of it in *Hispania*. This mill will, nonetheless, proliferate later under the Islamic rule in *Al-Andalus*, and will remain the principal means of grinding flour until Contemporary times. Windmills, will play a minor role in grinding grain and will be limited specifically to regions where water was not accessible.

Fig. 3.1: Schematic representation of the 3 major types of grain mills produced in quarries according to their motive forces: handmills driven by the arm; "à sang"mills driven by man or animal; water and wind-mills driven by harnessing natural forces (drawing by T. Anderson).

3.2. The saddle quern

The earliest grinding mechanism known in our study area is the saddle quern (fig. 3.2) comprising an elongated concave or flat nether stone and a smaller rubber or *mano* ("hand" in Spanish) active stone. Known since the Neolithic, this type of mill endured for centuries in a variety of forms, sizes and rock types before giving way, toward the middle of the first millennium BC, to the rotary quern and larger man-driven mill (Alonso 2011: 56). There are potentially three saddle quern quarries in our study area: Zujaira (GR-12) (Anderson, unpublished), El Barronal (AL-10) (Haro *et al.* 2006) and Cabezo de Oliva (MU-2) (Agüera *et al*. 1999).

It is worth noting that a more sophisticated version of this early non-rotary mill, the Olynthian mill, known elsewhere in the Mediterranean, notably at Lattes (Py 1992: 185) and in the Sec shipwreck off the Island of Majorca (Arribas 1987), has not been identified in our study area.

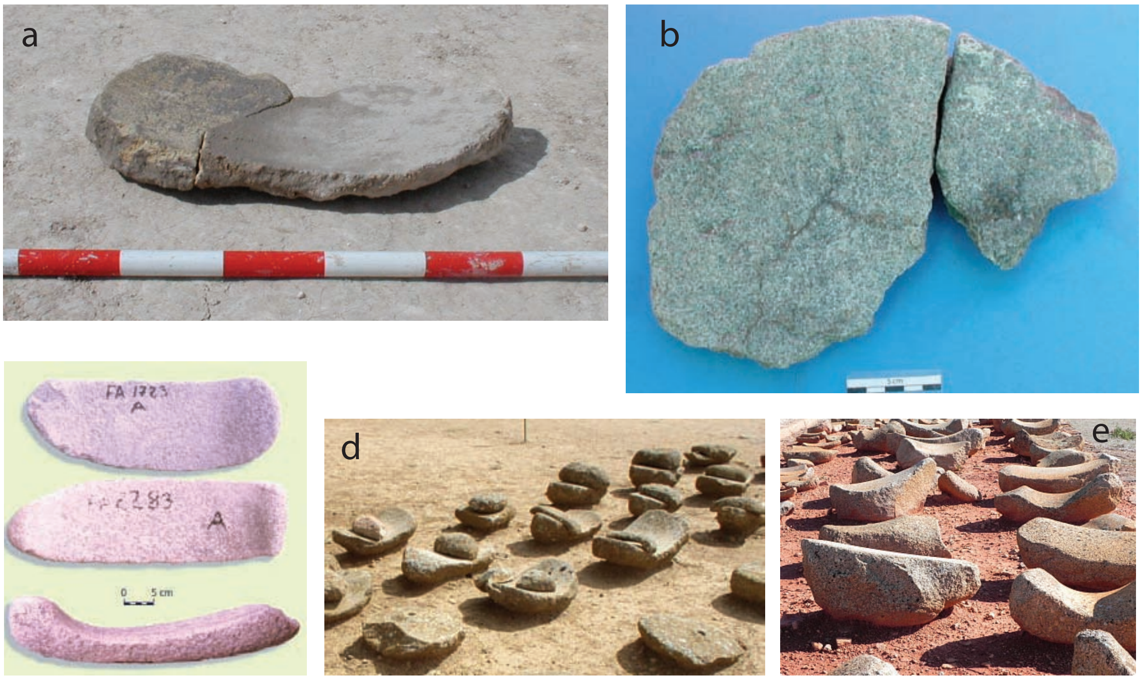


Fig. 3.2: Examples of saddle querns of various lithologies. a) Late Neolithic calcareous sandstone quern from the site of Los Pensadores (Granada), excavation T. Anderson, unpublished; b) Chalcolithic garnet-mica schist from Las Rajas (Granada) excavation T. Anderson, unpublished; c) Early Bronze Age garnet-mica schist querns from Fuente Álamo (Murcia); d) Iron Age sandstone and conglomerate querns from Numantia (Soria); e) granite querns from the Early Iron Age site of Cancho Roano (Badajoz) (photographs a, b, and d by T. Anderson; photograph c from http://www.elargar.com/caracterizacion/Artefactos/Instrumentos/; photograph e from blog of Jesús López, http://extremosdelduero.blogspot.com.es/2011/12/edificio-protohistorico-de-la-mata.html).

3.3. Generalities about the rotary quern

The rotary quern comprises two small circular stones assembled by means of different types of fittings. The upper stone (runner or *catillus*), mounted on a stationary lower stone (nether, *meta*), was driven by hand with steady, continuous circular motion. It was driven from a stationary position, probably at floor level as often seen in ethnographical studies, by one person with one leg outstretched and the other bent.

The product to grind (usually cereal) was gradually fed through the eye of the upper stone and exited in the form of meal or powder along the periphery of the stones and was gathered in a 'flour catcher', a cloth, skin or wooden box below the mill.

It is becoming more and more apparent that the mechanism was multi-functional. In fact, two recent Spanish studies of macroscopic remains show that rye and acorns were ground in rotary querns in pre-Roman times (Checa *et al*. 1999: 66-67), and fish for fish flour and fish oil, as well as cinnabar for pigments, in a Late Roman context (Domínguez & Bernal 2011: 457). Furthermore, handmills are known in Roman metal-working contexts possibly for grinding ore (García 2002: 620-621; Gutiérrez & Corpas 2011: 25-26), whereas recent rotary handmills were used to grind animal fodder.

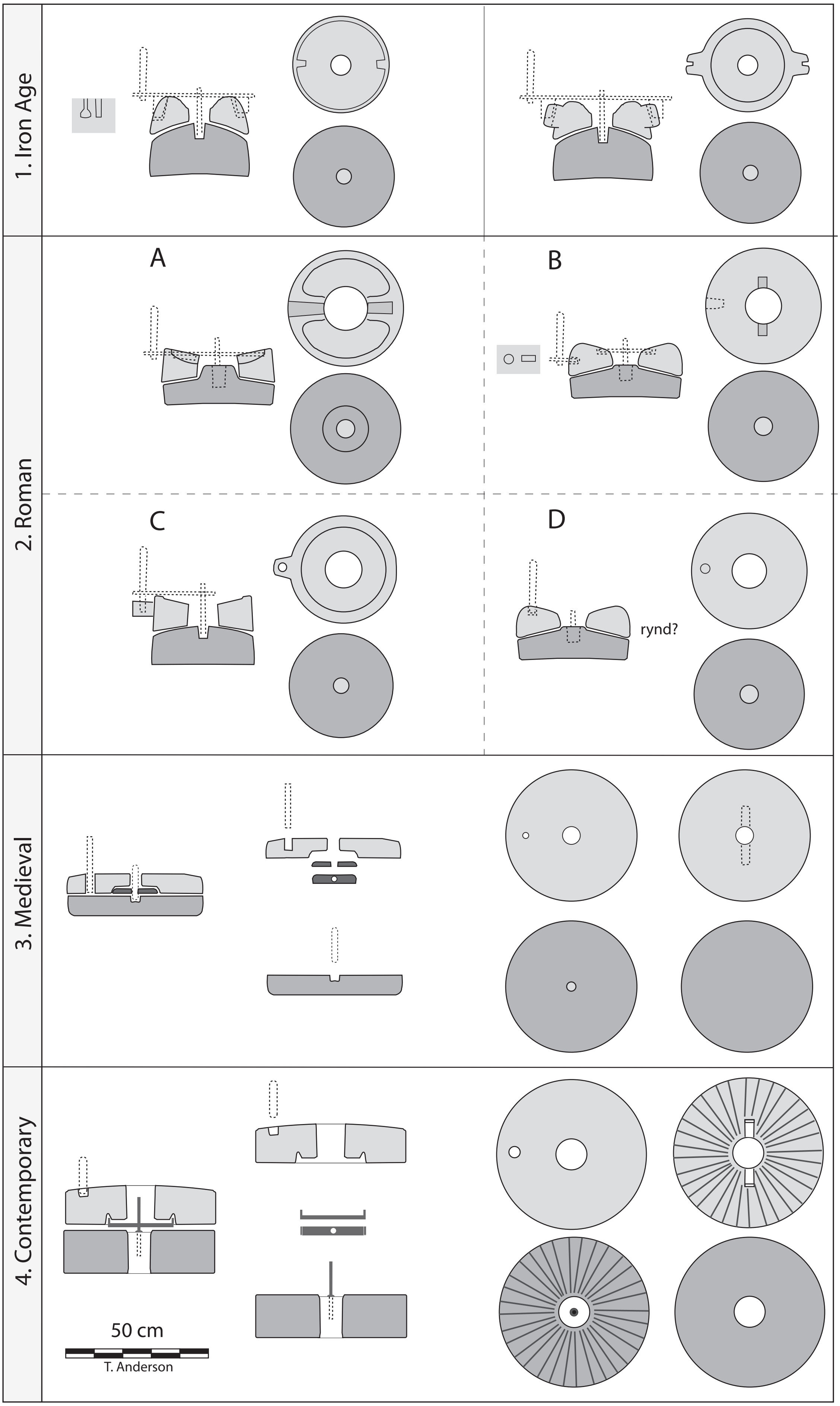
In terms of establishing quern typology, upper stones are much more susceptible to change than lower stones, due to the variety of means of traction and assemblage (handle and rynd cuttings). Basically, upper stones present two different types of profiles or sections that, at times, can reflect if they were scored from a surface block or from a quarry.

The first type of upper stone section is the hemispherical or domed upper stone, labelled "bee-hive" in the British Isles. Although it could be argued that this shape reveals the mill maker's desire to reduce weight, it is more probable that it reflects the fashioning of small surface boulders. When conditions of conservation are favourable, the boulder's original cortex can be observed on unknapped parts of the surface (Anderson *et al.* 2003: 42; Green 2011: 125; Pascual & García 2011: 287-288). The 'doughnut' profile upper stone is a variation of this type that also reflects the carving of surface boulders. Neither of these types, however, are common in the collections of southern Spain.

The second, and by far the most common quern section type, is cylindrical. Querns from true extractive quarries, scored directly from bedrock by means of cutting trenches, bear, almost invariably, vertical or slightly inwardly tilted edges (Anderson *et al*. 2003: 42). This shape is also characteristic of querns hewn from angular blocks previously pried from bedrock. Cylindrical querns therefore reflects a more complex, organised (possibly large-scale) type of work that contrasts with the simple collection and knapping of surface blocks. Cylindrical querns also benefit from the advantage that they are easier to stack for storage and transport.

In spite of the introduction of other more sophisticated and efficient milling installations, notably the watermill, rotary querns did not disappear at the end of Antiquity. As we will see in the following pages, as they endured through time, their morphology and fittings changed, culminating in their use for grinding animal fodder in Contemporary times.

In figure 3.3 we have attempted to condense the major typological changes of rotary querns from the Late Iron Age to Contemporary times. These features, in particular that of the size, along with the rock type, described individually below in their chronological context, make up the backbone of the criteria to date quern quarries.


1. Iron Age
2. Roman
A
B
C
D
rynd?
3. Medieval
4. Contemporary
50 cm
T. Anderson

3.3.1. The Iron Age rotary quern

Among the hundreds of rotary querns deposited in museums throughout southern Spain, less than a half dozen can be ascribed with a high degree of certainty to the Iberian Culture Iron Age. Most are devoid of stratigraphical context and are classified as pre-Roman by comparison with querns from Iron Age settlements elsewhere, notably in the northeast of the Peninsula. The exception is a small unit from the Late Iberian settlement of Cerro de la Cruz, Almedinilla (Quesada *et al.* in press). Based on a the few reasonably dated examples and on studies of Iron Age querns undertaken elsewhere in Spain (Burés *et al*. 1993; Checa *et al*.1999; Asensio *et al*. 2001; Guérin *et al*. 2003; Portillo 2006; Alonso *et al*. 2011), certain typological tendencies emerge (Anderson *et al*. in press) (cf. fig. 3.3).

Pre-Roman querns (fig. 3.4), to begin with, are systematically smaller (mostly between 30 and 35 cm in diameter) than their later Roman counterparts. Other unique features include opposite vertical straight slits, "L" shaped slots and "inverted keyhole" slots carved into the upper stone's edge to lodge the fittings to assemble and drive the mill. 'Inverted keyhole' cuttings are present among the querns of Numantia (Soria) and diverse sites in Catalonia (e.g. Burés *et al*. 1993: 134, fig. 14; Asensio *et al*. 2001: 68, Plate 6, M-7 and M-17). In our study area this feature is seen on the examples at the Municipal museum of Jódar (Jaén), los Ventorros de San José (Granada) and the excavation of Cerro de la Cruz (Almedinilla, Córdoba) (Quesada *et al*., in press) (fig. 3.4 d,e). Opposite ear-like lugs (fashioned directly from the rock) with vertical cuttings are also known such as an example on display in the Municipal Museum of Alcalá la Real and in a private collection at Zujaira, Granada. Lug with "inverted keyhole" or vertical slit cuttings seems to be characteristic of the Iberian Culture. Lugs alone, though, are not a conclusive criterion for dating because they are also present, although not common, on Roman models.

As in the case of the earlier saddle querns, no Iron Age quern quarry has been identified in the field.

Fig. 3.3: opposite page. Schematic representation of the major rotary quern types in southern Spain from the Iron Age to the Contemporary period. In general, querns progressively increased in diameter while grinding surface angles decreased becoming flat. Handle cuttings shifted from opposite lateral slots to a single hole on the upper surface and rynd fittings relocated from the top to the bottom (from Anderson et al.*, in press).*

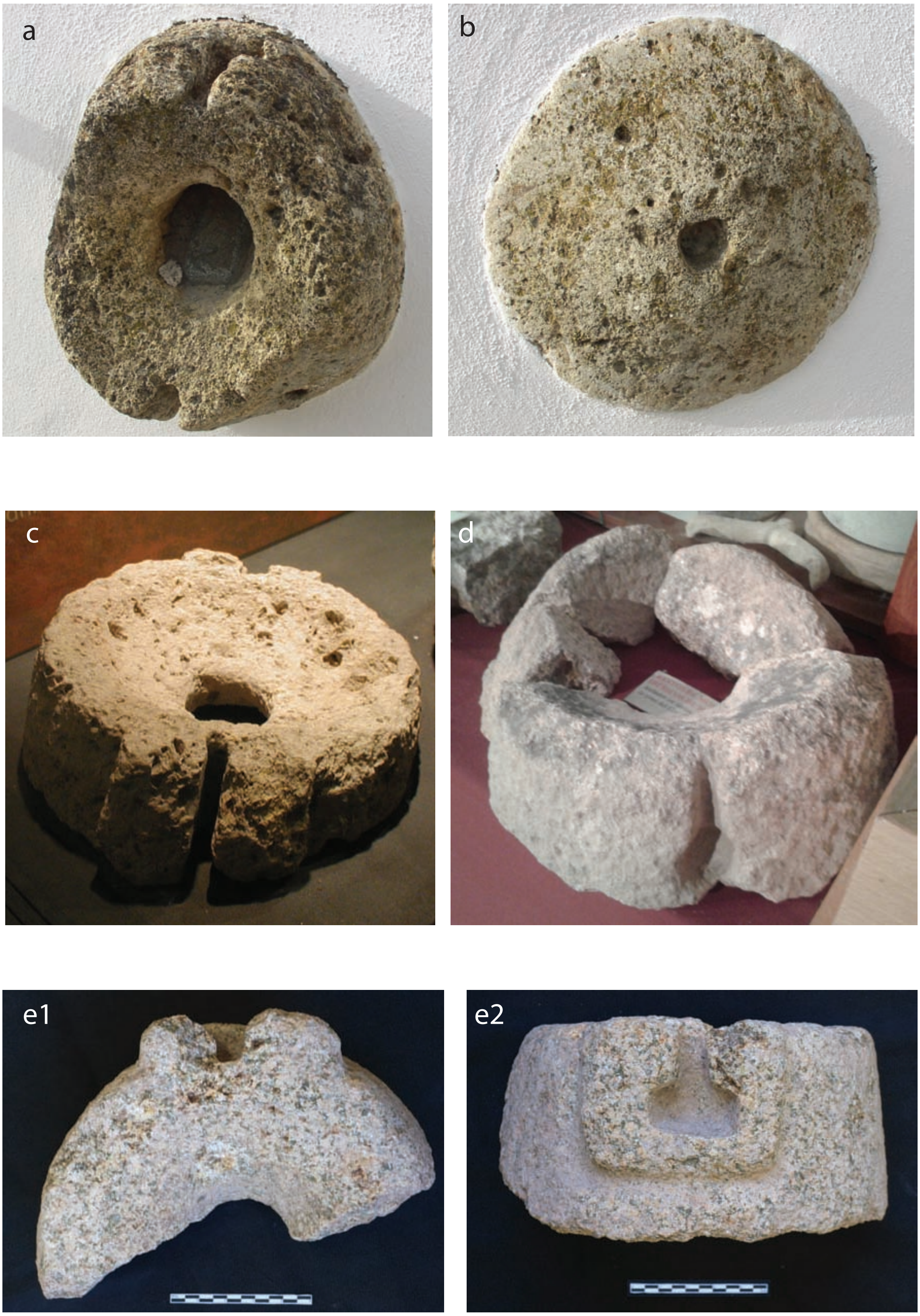


Fig. 3.4: Examples of rotary handquerns attributed to the Iron Age. a-b) Upper stone (ø: 32 cm) and lower stone (ø: 34 cm) from Ventorros de San José (Granada), possibly a pair; b) upper stone with lugs with vertical slits (Alcalá la Real, Jaén); upper stone (ø: 38 cm) with inverted "keyhole" handle cuttings (Jódar, Jaén); and e) top and side view of an upper stone with lug and inverted "keyhole" cutting (Cerro de la Cruz, Almedinilla, Córdoba). Petrography: a-c) porous limestone; d) probably conglomerate; e) granit (from Quesada, F., Kavanagh, E., Lanz, M. 2014, nº cat. 7, fig. 6).

3.3.2. The Roman rotary quern

Roman rotary querns (cf. fig. 3.3) are typical finds at excavations of Roman rural settlements, towns and cities. They are at times unearthed in conjunction with other more complex, industrial, milling equipment such as cylindrical mills and Pompeian mills (see below). The number of Roman hand-querns in our study surpasses by far that of querns from all the other chronological periods together. This higher number can be attributed, in part, to the disproportional focus of fieldwork on the Roman period. It certainly also reflects, when compared with the preceding Iron Age Iberian Culture, an ever-growing population in Antiquity.

The most common type of upper stone (*catillus)* (fig. 3.3a and fig. 3.5) in southern *Hispania* is cylindrical. It is bordered by (a) a rim and by the eye has two receptacles (b) for grains (shaped like bat wings) separated by opposite (c) radial handle slots. The grains were fed progressively from these hopper-like receptacles into the mill, through the eye, means of vibration and gravity. The radial slots served to lodge (d) an iron bar or crosspiece (never conserved), about 45-50 cm long and about 3 cm wide. The hole in the centre of the crosspiece (like the hole of a rynd, coupled with the (e) the spindle of the lower stone, served to assemble the mill and maintain it centred during rotation. Its projection beyond the mill to one side through a gap in the rim served also as a base for (f) a vertical handle (fig. 3.6a; fig. 3.7). Two examples in our study area indicate that the iron crosspiece was secured by (g) molten lead (Palomo & Fernández 2007: 357, fig. 8; Linares museum, inv. no. CE02430).

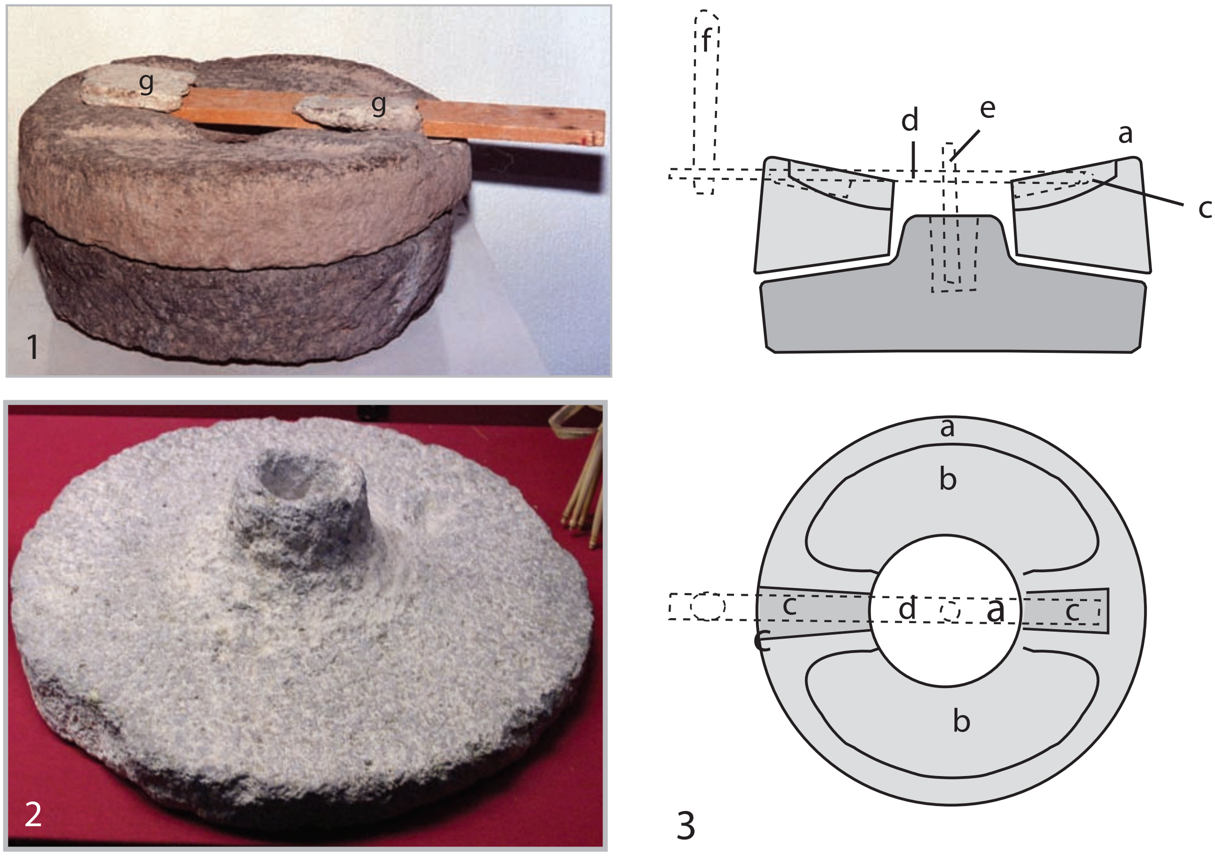


Fig. 3.5: 1) Roman quern upper stone (ø: 39 cm) (photograph by the Museo Arqueológico de Linares, Jaén; 2) Example of a "sombrero" type lower stone (ø: 36 cm), Museo Municipal de Úbeda. Both are of volcanic rock. 3) Schema illustrating the assemblage and driving fittings (drawing by T. Anderson).

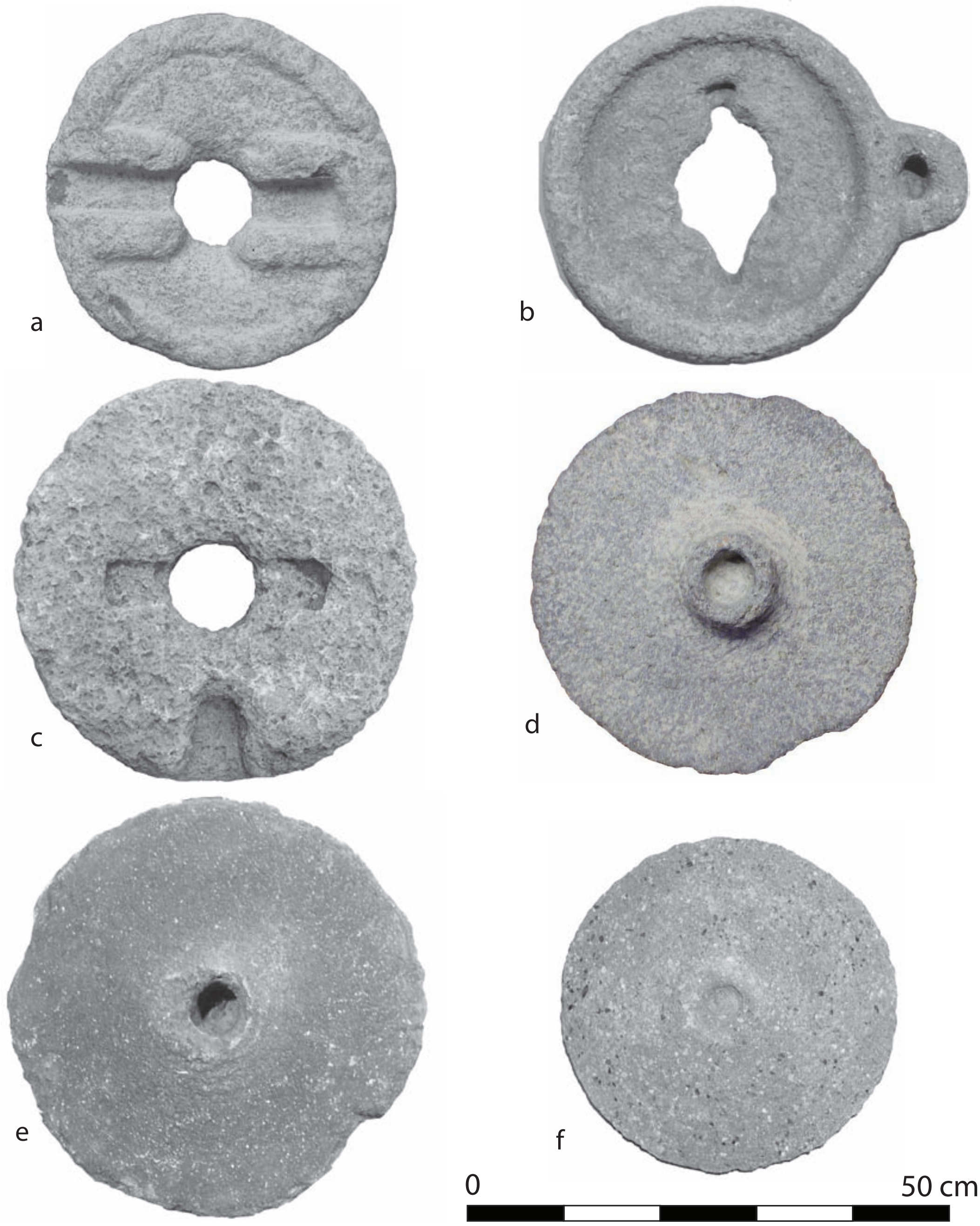


Fig. 3.6: Examples of the typological and lithological variety of Roman rotary handquerns a) upper stone rim and radial cuttings (Priego de Córdoba); b) upper stone with rim, handle lug and rynd cuttings (Murcia); c) upper stone with no rim, single radial cutting and rynd cuttings (Baelo Claudia, Cádiz); d) lower stone with prominent collar ("sombrero type") (Úbeda, Jaén); and e-f) conical lower stones (Murcia). a, b, d, e) volcanic rock; c) biocalcarenite; f) conglomerate.

Other types of Roman *catilli* are less frequent. A second example is characterised by a horizontal socket cut into the edge of the upper stone destined to lodge a lateral handle (cf. fig. 3.3b). This hole is most often circular, rarely rectangular. It is worth noting that although this is probably the most common type of Roman quern handle fitting elsewhere in Europe, it was not adopted on a large scale in southern Spain.

A third type of Roman *catillus* was driven by one (rarely two) lateral lugs bearing a vertical handle socket (cf. fig. 3.3c). This handle is independent from the rynd, probably of iron, lodged in two small rectangular cuttings upper surface on opposite sides of the eye.

Fig. 3.7: Reconstruction of a Roman domestic milling scene in the south of Spain. The catillus *bears a horizontal crosspiece (handle and rynd rig) fastened with lead in radial slots (drawing by T. Anderson, from Anderson* et al. *in press).*

A fourth upper stone type, also not widespread, had a vertical handle socket cut into the upper surface. This was the most simple of handle fitting, and dates, presumably, to the transition from Late Antiquity to the Early Middle Ages (cf. fig. 3.3d). It is still unclear if the rynd slots are on the top or the bottom of the upper stone. In any case, the vertical handle hole on the upper surface became predominant in the Middle Ages and has endured until recent times.

It is noteworthy that no example of "elbow" handle hole cutting (joining the edge with the upper grinding surface meant to lodge a metal sleeve for a wooden handle), known elsewhere notably among the volcanic productions of Catalonia (Vivar 2004: 104, fig. 1) and the Eifel (Anderson et al. 2003: 42, fig. 32,2) is not present in our study area

Lower stones in general show few typological features and hence, when devoid of context, are more difficult to date. The Roman upper stone cited above with the radial handle and rynd cuttings is associated with two types of lower stones (*metae*). The first consists of the "normal" conical model with or without a small lip around the eye (resulting from wear). This is the most common type of *meta* known throughout the Roman world.

A second type of lower stone presents a unique feature: a prominent collar around the eye (fig. 3.3a and fig. 3.6d). This collar is a premeditated feature carved at the quarry and not a result of wear. Although analogous collars are known on upper stones elsewhere in Europe, notably in the rhyolite productions of the Esterel (Désirat 1996: 133, fig. 59; Longepierre 2011: fig. 101) in southern France (to facilitate feeding the grains), this morphological feature seems to be unique to Roman lower stones in southeastern Spain. It is not documented in the assemblages studied by Portillo in Catalonina (2006), or those of M. Py (1992) or S. Longpierre (2011) in southern France. The closest example is a lower stone from *Conimbriga* (Borges 1978: 127, no. 52; Plate VII, 52). But the example from Portugal is of granite and is not cylindrical. For this reason, the lower stones produced at the Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2) are labelled the *sombrero* type (cf. fig. 3.5.2)

Although most often associated with domestic activities, querns are also well known to have formed part of the equipment of the Roman army. All said, no examples incised with military inscriptions along their edge have been brought to light in Roman *Hispania*.

A number of Roman rotary quern quarries have been identified in our study area, notably the volcanic sites of *Sisapo* in Ciudad Real (CR-1) and Cerro de Limones and Hoya del Paraíso in Almería (AL-1, AL-2), as well as the *ostionera* sites of Trafalgar (CA-1) and Rota (CA-3) in Cádiz.

3.3.3. The Medieval rotary quern

If progress has been made on the understanding of querns and quarries of the Roman period, research on Medieval querns and quarries is still in a nascent stage. There is a huge gap corresponding roughly to the thousand years of Visigothic and Islamic domination. The number of querns in museum depositories, due to a scarcity of archaeological interventions, is limited and few are described or illustrated in the specialised literature. The notable exception is the dozen from a settlement in Montefrío, Granada (Motos Guirao 1987: 465-467, 473-474, 479-480, PL. I-IV). From this group, as well as a observations in museums (in particular in Murcia), Medieval querns can be distinguished by their differences with their earlier Roman counterparts (cf. fig. 3.3; fig. 3.8; fig. 3.9).

Their first difference is their size. Although there are still small models, between 30 and 40 cm (even very small models at approximately 20 cm in diameter, fig. 3.9), most measure between 40 and 50 cm, well above the average diameter of a Roman quern. A second major difference is that the general shape is flatter, discoidal, with practically horizontal grinding surfaces. Upper stones also are devoid of rims and receptacles for grains and the driving feature a simple vertical hole for a vertical handle cut toward the edge of the stone. This system is a world apart from the older Roman radial handle cuttings. The diameter of eyes also decreases and rynd cuttings appear to relocate from the top to the base of upper stones.

The evolution from a steep grinding surface angle to a practically flat grinding surface suggests that cereal grains (or other product) were fed directly into the eye of the upper stone and not in a hopper-like receptacle. The systematic change of the handle fitting from a radial groove to a vertical socket might indicate that the upper stone was driven with a long vertical rod connected, for example, to the ceiling of the house. Another option is that it was driven by a horizontal connecting rod. All said, these driving systems profiting from torque are hypothetical.

Several quarries of this mill type have been identified in our study area, notably at Zagra (GR-5) and Almadén de la Plata (SE-1).

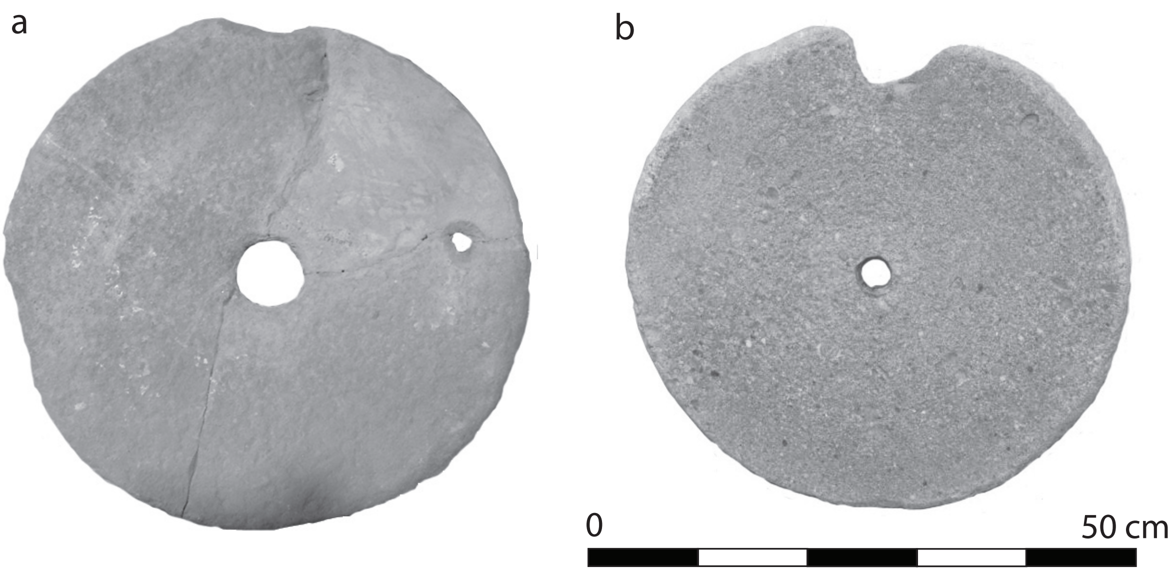


Fig. 3.8: Medieval discoidal rotary querns: a) Upper stone ø: 48 cm (Murcia); b) lower stone ø: 47 cm (Siyâsa, Murcia). The eye of the lower stone shows traces of iron oxide indicating an iron spindle.

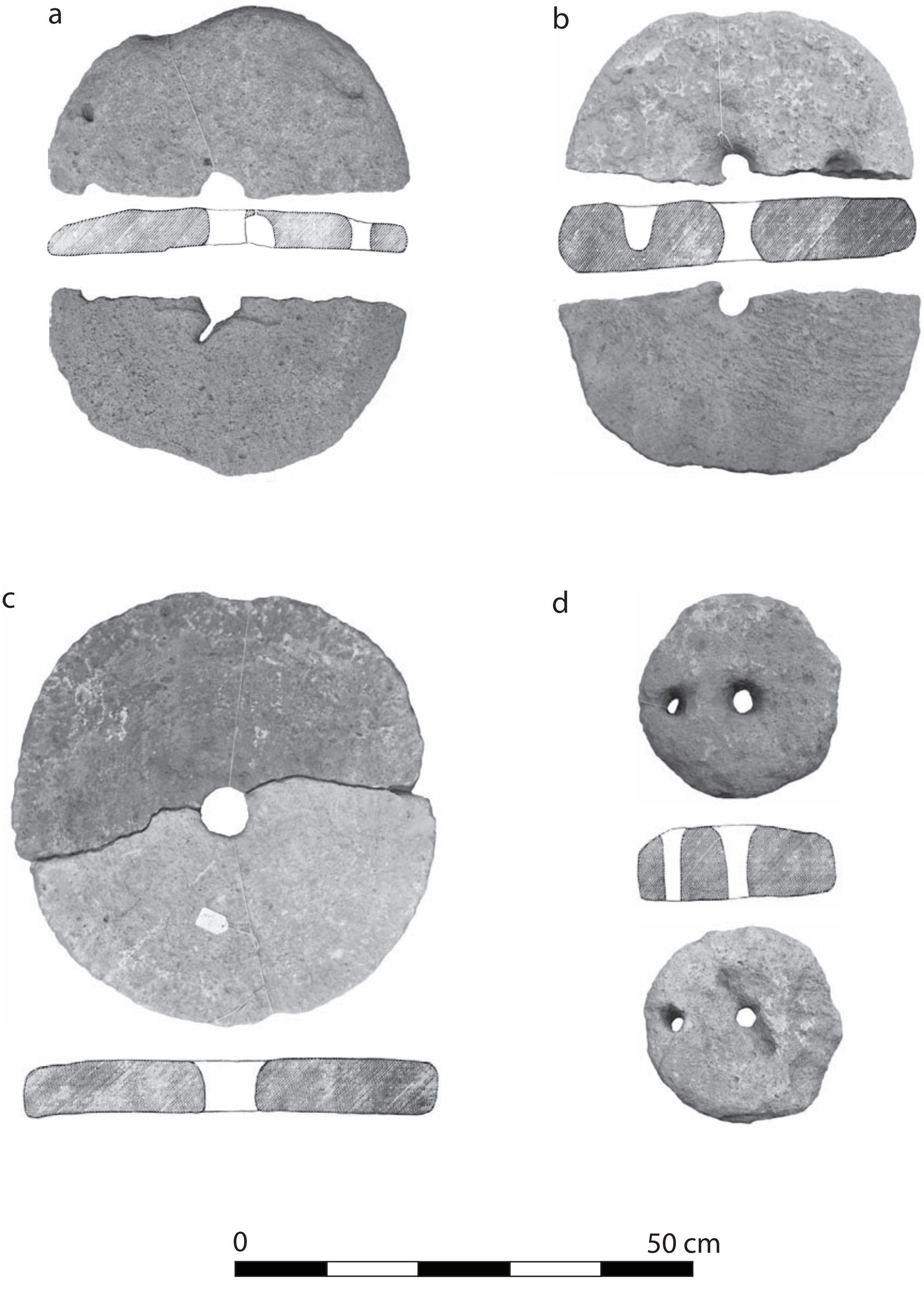


Fig. 3.9: Rotary querns from the 1981 excavation of the Medieval settlement of El Castillejo, Montefrío (Granada) dating from the 9th to the 12th century (Motos Guirao 1987: 480). a) Upper stone with handle hole and lower rynd cutting, ø c. 38 cm; b) upper stone with no rynd cutting; c) lower stone; and d) upper stone with handle and rynd cutting of a very small hand-quern (photographs by T. Anderson; the sections from the original drawings from Motos Guirao 1987, plates I-III).

3.3.4. The Contemporary rotary quern

Contemporary rotary querns are spread throughout the rural landscape of southern Spain. They differ from earlier querns in that their principal use was to grind animal fodder (*molinos de cebo*) (fig. 3.10). All the same, it is known that some of these mills ground foodstuffs for human consumption in times of crisis, notably in the dark years after the Spanish Civil War. In Priego de Córdoba (Córdoba), M. Campos has collected a dozen complete mills (both upper and lower stones) from abandoned farms that we have been able to examine.

These querns distinguish themselves from their older counterparts, first of all, by their larger size (often surpassing 50 cm) and weight. Their driving fittings are standardised: a vertical handle socket carved into the upper surface near the edge and rynd cuttings on the lower

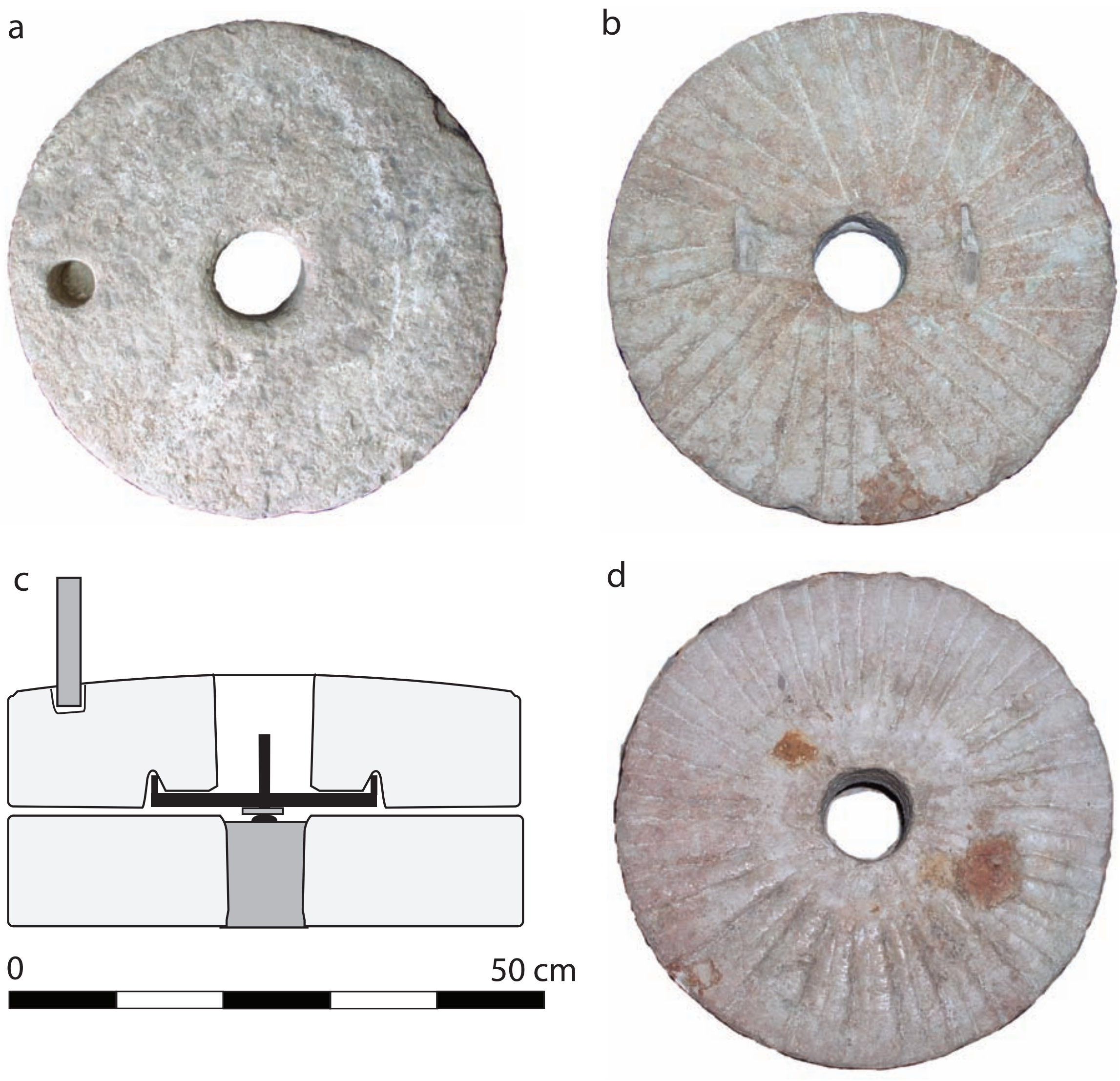


Fig. 3.10: Example of a Contemporary animal fodder handmill measuring 47 cm in diameter from the area of Priego de Córdoba with reconstructed handle and rynd. These mills were also presumably served to grind foodstuffs for humans during dire times. a) upper stone, top view b) upper stone working surface c) section d) lower stone working surface.

surface. These cuttings are variable, from the single opposite rectangular slots to complex cruciform slots (possible repairs). Lower stones are always totally perforated. Their iron spindle is plugged with wood or plaster.

Another specific characteristic that differentiates them from earlier hand-querns is the systematic presence of radial or harp-shaped furrows on the grinding surfaces of both upper and lower stones. Most of these finds, according to M. Campos, were still in their working position on ledges at table height near the stables of the farms. In this sense they differ from most earlier models.

Other similar animal fodder mills are known elsewhere in Spain (e.g. Pascual *et al.* 2010). Their driving mechanisms differ greatly, however, in that instead of being driven from above with a handle, they were driven from below with connecting rods and cranks (fig. 3.11). For this reason these models do not have handle holes.

The precise location of the production centres of these mills is not known. It is probable that they were carved from detached angular blocks, a technique that leaves little characteristic evidence in the field.

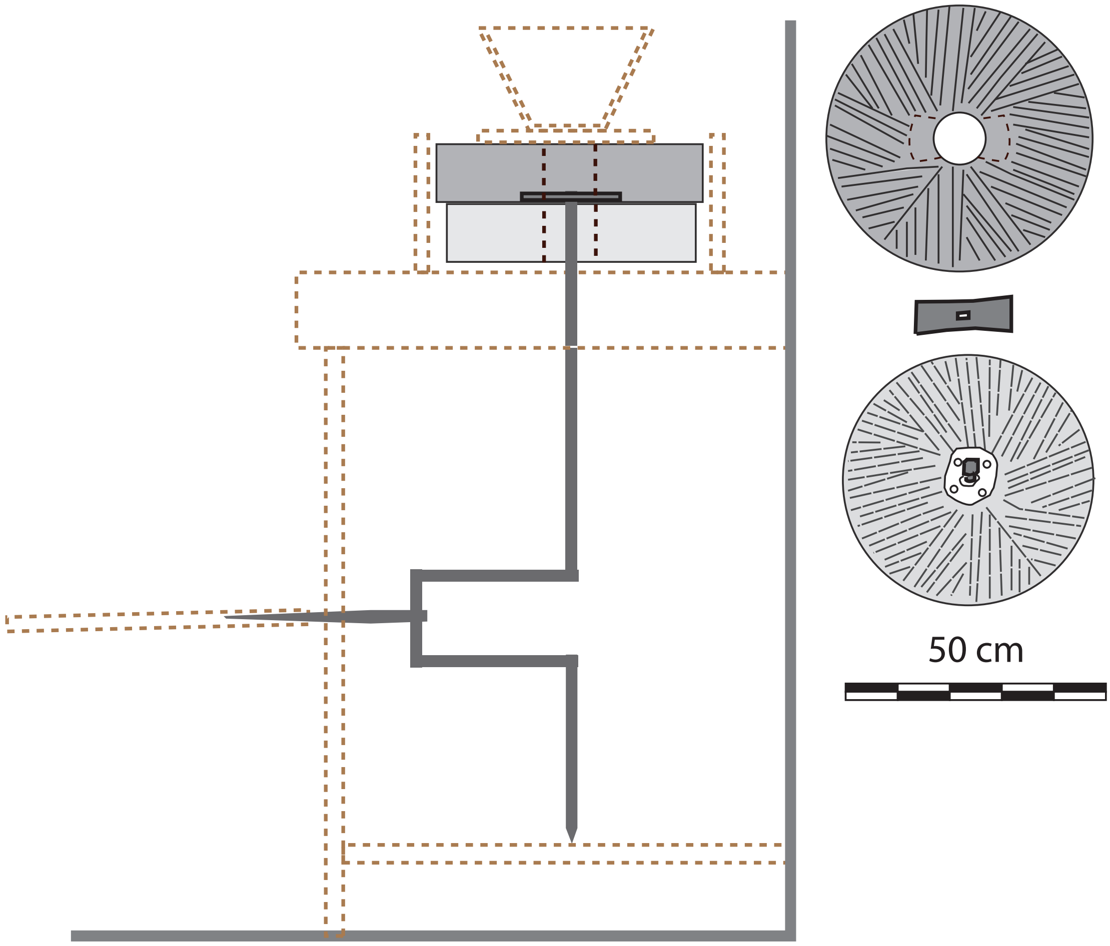


Fig. 3.11: Schema of the Contemporary (20th century) handmill from Cubo de la Sierra (Soria). Since the driving force is transmitted from below by means of the connecting rod, drive shaft and rynd, the upper stone has no handle socket. These stones are often of conglomerate (drawing by T. Anderson, from Pascual et al. *2010, 10, fig. 5).*

3.4. Man or animal-driven millstones

These mills differ from rotary querns in that they are larger and thicker and are driven either by man or by animal from a standing position. They therefore require a peripheral ambulatory space. Some are known to have been set on podiums that not only raised the mill, but served as flour catchers. The origin of the driving force is in the legs and body and not in the arm. Since the driving force is not always evident (man or animal), in Spanish and French these are known as "blood mills" (*molino de sangre* and *moulin à sang*). There is no equivalent in English.

These mills are assembled by means of a wooden frame, toped by a horizontal lever, lodged in the lateral slots of the upper stone and into the spindle of the lower stone. They are turned by pushing the horizontal lever. The lateral cuttings are usually larger at their base so as to fasten the wooden frame and allow it, by lifting the lever, to be removed for maintenance. The earliest examples in our study area are found in Iron Age settlements.

Models practically identical to the Iron Age mill remained in use in Roman *Hispania* in the form of cylindrical mills with "ring-*catilli*". The other Roman man- or animal-driven mill was the Pompeian hourglass mill. It is also worth noting that the Morgantina mill (the precursor of the Pompeian mill), is not recorded on the Iberian Peninsula.

3.4.1. The Iron Age mill

Iron Age man driven-mills (fig. 3.12) comprise a roughly cylindrical, ring-shaped upper stone with a "D" section and a lower stone with a steep grinding surface topped by a square spindle hole. After extended wear, the lower stone diminishes in width, resulting in an elongated neck with an inwardly inflected grinding surface. The wooden frame is usually lodged in vertical

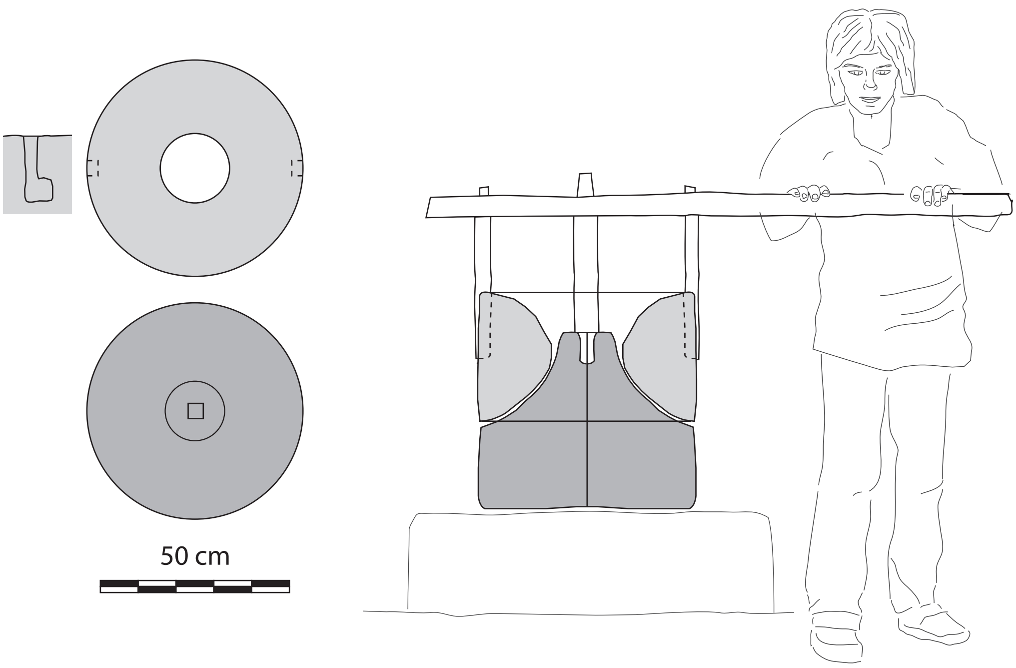


Fig. 3.12: Schema and reconstruction of a Late Iberian Culture man-driven mill (drawing by T. Anderson).

slits, “L-shaped” or “inverted keyhole” lateral cuttings (Berrocal Rángel 2007: 292) which permits the lever also to serve as a means to lift and remove the upper stone for maintenance. The eye of the lower stone is square or rectangular. Presently, there is no evidence that they were driven by animals.

Although these mills are reported at a number of Iberian Iron Age sites in our study area, notably Baza (Granada) and Jódar (Jaén), the only examples from secure chronological contexts brought to light in the last years at the hilltop settlements of Cerro de la Cruz, Almedinilla (Jaén) (Quesada *et al*. 2010: 88-89) (fig 3.13-3.14) and Castrejón de Capote, Higuera la Real (Berrocal Rángel 1989: 258; 284, fig. 26.1).

Only one quarry district of this Iron Age mill has been identified in the field. It is the limestone tufa outcrops around the town of Almedinilla, very near the settlement of Cerro de la Cruz.

Fig. 3.13: Views of an Iron Age, man-driven mill (diameter 60 cm) from the Iberian settlement of Cerro de la Cruz (Museo Histórico–Arqueológico de Almedinilla). The stone is a local “travertine”. The L- shaped lateral cuttings served both to lodge the wooden driving fittings and to lift the stone for maintenance (photographs by T. Anderson).

Fig. 3.14: Iron Age “travertine” man-driven mills in situ *at the Cerro de la Cruz. a) The broken upper stone in the background mill has slipped down to the base of the lower stone, diameter 60 cm; (photograph from http://www.rutasconhistoria.es/loc/poblado-ibero-el-cerro-de-la-cruz). b) an extremely worn “travertine” lower stone* in situ *on a rock-built podium at the Cerro de la Cruz, diameter: 59 cm (photograph by T. Anderson).*

3.4.2. The Roman cylindrical mill

Roman cylindrical mills share the ring-shape, D-section, straight vertical edges and lateral cuttings and a conical or bell-shaped lower stone (fig. 3.15) with their Iron Age forbearers. For this reason, when devoid of context, it is not always possible to differentiate the Roman from the Iron Age models. They differ in that Roman models are usually larger and their lateral cuttings are more often of dove-tail shape. This mill is also labelled the *Volubilis* type because of it presence in this Roman city in northern Morocco (Luquet 1966: 306, fig. 3B; Akerraz & Lenoir 2002; Longepierre 2011: 1000). A similar mill, labelled the Haltern-Rheingönheim type, is known in the Rhine Valley in Germany with examples as far south as Basel and Avenches in Switzerland (Anderson *et al*. 2004: 11).

It is becoming more and more clear that this type of mill is directly related to the olive oil industry. As Peña Cervantes has noted, of the 35 oil installations documented excavations, 10 of them have this type of mill (2010: 66). An example is the *in situ* mill at Munigua, Seville, in the same room, two steps away, from an oil press (Peña Cervantes 2010: 146, fig. 52). There are, however, a number of arguments, developed in the conclusions of this study, that suggest the mill was "multifunctional" (a term borrowed from J.-P. Brun), used both for crushing olives and for milling cereals (Akerraz & Lenoir 2002; Peña 2010: 574, 576,750). All said, much work remains to be done on this question from both the point of view of typology and analyses of vegetable remains, in particular phytoliths.

There are at least a dozen ring-mill upper stones (*anneaux*) reported in the survey of M. Ponsich of the Guadalquivir River valley (Ponsich 1974, 1979, 1987, 1991). A granite example is known at *Conimbriga* in Portugal (Borges 1978: 125, no. 31) and a volcanic model is on display in the museum of *Castulo* in Linares (Jaén) (inv. CEO1429) (fig. 3.16-3.17). There are other examples of varying lithology throughout museums of southern Spain in Murcia, Osuna (Seville), Mérida (Badajoz), Granada and Almería.

As has been pointed out (Anderson *et al*. 2011: 154), the morphometric similarity of cylindrical and Pompeian lower stones has engendered confusion as to their identification (fig. 3.18). The tendency in archaeological literature is to link them directly with Pompeian mills without

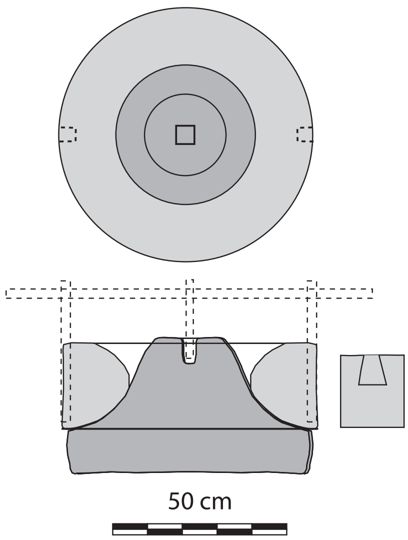


Fig. 3.15: Schema of a Roman ring-mill (drawing by T. Anderson).

Fig. 3.16: Volcanic ring catillus *from the Roman city of* Castulo *(Jaén). The type of rock of the lower stone (not the original pair) has not been determined. ø: 64 cm (photograph from Linares museum, inv. no. CE01430_R).*

considering that they could be coupled with ring-mills. This confusion is heightened by the relative low spread of upper rings, due to their fragile nature rendering them difficult to recognize in a fragmented state.

The sites of *Sisapo* (CR-1) and Bolaños (CR-2) are the best examples of quarries producing these mills. There is also strong evidence of production at the volcanic lamproite outcrops in Murcia.

*Fig. 3.17: Examples of granite Roman ring-mill upper stones (*catilli*) measuring about 70 cm in diameter in the National Museum of Roman Art, Mérida (Badajoz).*

*Fig. 3.18: Roman man or animal-driven lower stones (*metae*). When the lower stone is separate from the upper stone, it is difficult to determine the mill type (flour or oil). Due to the rarity of Pompeian mills in southern Spain, these lower stones were probably coupled with ring-type* catilli*: a-b) Almedinilla museum (Córdoba), ø base: 62 cm, sedimentary rock; ø: 68 cm, volcanic rock; c) Albolote (Granada), inv. no. CE14119, ø: 83 cm, sandstone (photograph http://www.juntadeandalucia.es/culturaydeporte/WEBDomus/fichaCompleta.do?acron=MAEGR&musid=9&ninv=CE14119&volver=portal&k=CE14119&tipoBusqueda=simple); d-e) Oreto-Zuqueca (Ciudad Real) ø: 55 cm, ø: 73 cm, volcanic rocks; f) Fuente Álamo (Murcia) ø: 53 cm, volcanic rock.*

3.4.3. The Roman Pompeian mill

The Pompeian mill is the best known of the different mills and are known throughout the Roman Empire (fig. 3.19). With its typical hourglass-shaped upper stone (*catillus*) with lateral sockets for the driving rig and conical or bell-shaped lower stone (*meta*), this mill was either driven by a donkey, as seen in Antique iconography, or by man. Although the most celebrated examples are found in Italy in the ancient bakeries of Pompeii and Ostia (Peacock 1989), isolated models are known as far as the Eifel in Germany (Hörter 1994: 32-33) and the British Isles (Williams & Peacock 2011). Recent work in France reveals a great number distributed throughout the Narbonese province (Jaccottey & Longepierre 2011). Although most are imports of volcanic rock presumably from the volcanic district of Orvieto (Italy), there are also copies, especially in the north of France, hewn from local sandstone (Jaccottey & Longepierre 2011).

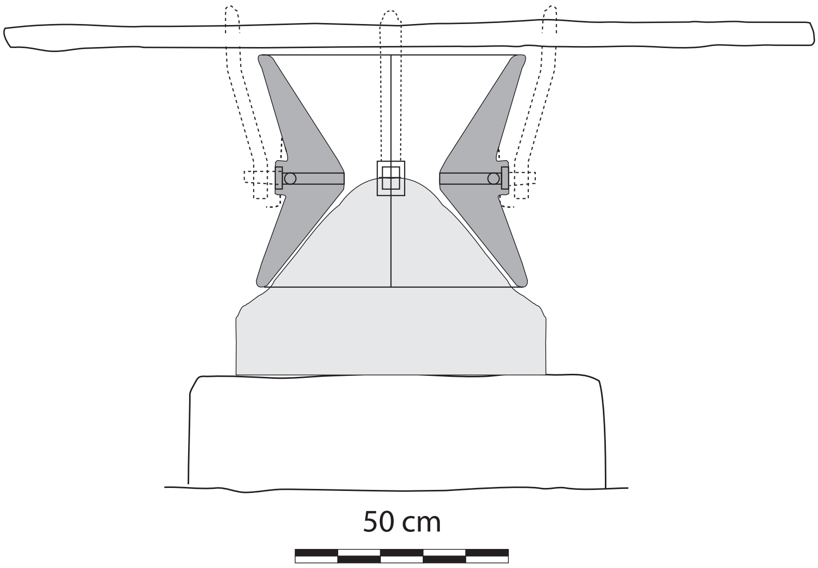


Fig. 3.19: Schema of a Pompeian animal or man-driven mill (drawing by T. Anderson).

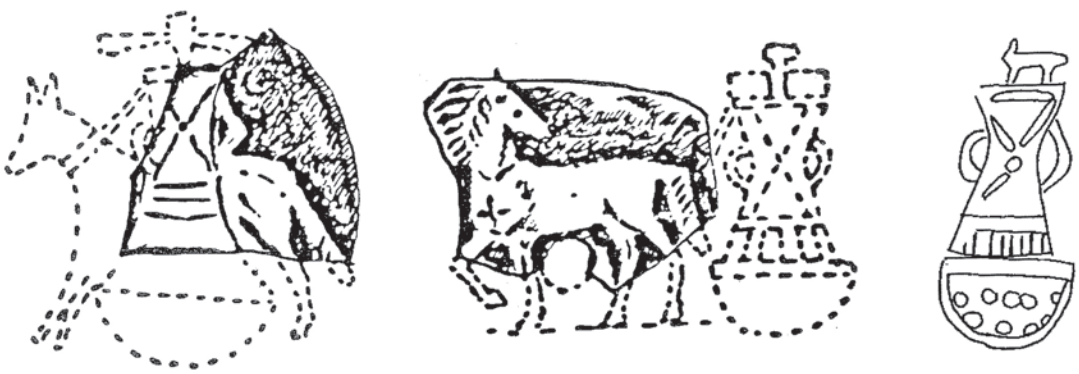


Fig. 3.20: Representations of Pompeian millstones on Roman lamps. a-b) Bilbilis, *Zaragoza (from Amaré 1988, p. 83-84, fig. 152-153); c) Murcia (from Amante 1988, p. 227, pl. IV, 72).*

In contrast to the situation in France, recent research in Spain presented at the Lons le Saunier colloquium suggests that this type of mill was not widely adopted in Roman *Hispania* (Anderson *et al*., in press). Contrary to Italy and France, there are no iconographic representations such as bas reliefs on Iberian soil. The only confirmed images of Pompeian mills are sketches on Roman oil lamps from Zaragoza (Amaré 1988) and Murcia (Amante 1988) (fig. 3.20). It is not known if these images on locally produced lamps are copies of representations from imported examples or if they were inspired from mills in use in Roman urban centres of *Hispania* (Amaré 1988; Amante 1988). In any case, at the present, only a dozen confirmed Pompeians are known for the whole of the Peninsula. Most are of volcanic material, probably imports from long-distance quarries elsewhere in the Mediterranean.

There is, nonetheless evidence, albeit modest, of some Pompeian production in *Hispania*. A *catillus* roughout of local *ostionera* rock is in the *lapidarium* of the Roman city of *Baelo Claudia* (Cádiz) (see CA-2a), while a second *catillus* from ancient *Malaca*, hewn presumably from a porous local limestone, , is in the Museum of Málaga (fig. 3.22).

The is no hard evidence to link any Pompeian workings to either of the volcanic districts of our study area. A minute example in the ARQVA museum of Cartagena could, potentially, have been scored at a nearby Murcia volcanic outcrop (Anderson *et al*., in press). In any case, the nearest Pompeian volcanic production, signalled by Williams-Thorpe (1988), is across the Mediterranean in northern Morocco at Farkhana. Two hourglass shaped roughouts in the archaeological Museum of Melilla, a short distance from Farkhana, confirm this production centre.

Fig. 3.21: Pompeian mill from Mazarrón (Murcia). Recent analyses indicate this volcanic mill is probably an import from the volcanic district of near Orvieto, Italy. The lower stone and podium are reconstructed (photograph Museo Arqueológico de Murcia).

Fig. 3.22: Pompeian upper stone from the Alcazaba de Málaga. This porous limestone (?) is possibly a local copy of an imported volcanic millstone.

3.4.4. The Medieval to Contemporary *tahonas*

The *tahona* (sometimes written *taona* or *atahona)* (fig. 3.23), according to the dictionary of the *Real Academia Española*, is a flour mill driven by *caballería* (i.e. horse, mule or donkey). This mill was the natural heir of the Roman "donkey" mill tradition. The term derives from the Arabic *at-tahuna* "mill". An alternate definition of the word *tahona* is bakery. These different definitions, at times, lead to confusion as to if a text refers to a mill or a bakery.

The *tahona* was an alternative to watermills and windmills. The early 17th-century *Covarrubias* dictionary explains these "dry" mills were found in fortifications and other features devoid of sources of running water (Covarrubias 1611: 99). The medieval *tahona* in the Fortress of Calatrava la Nueva (Aldea del Rey, Ciudad Real), for example, is perched on the top of a mountain (fig. 3.24).

It is beyond the scope of this study to describe in detail the technical features of this mill. All the same, we note that in our study area, two types of Medieval *tahonas* are described among the mills of the region of Córdoba. The first was driven by direct horizontal traction from the animal, whereas the second, had a more complex gearing system similar to that of watermills (Cordóba de la Llave 1988: 839-840). The author, however, specifies that no mills of either type have been identified in the urban Córdoba, dominated by watermills. Accordingly, recent research has identified no *tahonas* in the Alpujarra mountains of the Province of Almería or in the neighbouring areas of Murcia and Granada (Caro Barrionuevo 1999: 148). K. Lizarralde, in his counting of the mid-19th century mills from the Madoz dictionary, only itemised 1,476 *tahonas* of the total of 25,000, representing less than 6% of the total number of mills. It is therefore apparent that *tahonas*, from Medieval to Contemporary times, took on a secondary role to that of watermills.

Millstones specifically destined to *tahonas* were produced at certain quarries in our study area, for example at the white limestone exploitations of Colmenar de Oreja (M-2) and El Berrueco (CA-8). Madoz states that the production of Colmenar de Oreja was destined to the *tahonas* of the city of Madrid (Madoz 1847, Vol. 6: 525). In the case of El Berrueco, he specifies that, besides the yearly production of 64 millstones for water or windmills, the quarry made 480 *granos* for *tahonas* (Madoz 1846, Vol. 4: 290). The existence of a specific term *grano*, literally meaning "grain", suggests it was morphologically different than that of watermills and windmills (possibly smaller). This is purely theoretical and has yet to be confirmed.

In any case, the extraction process for millstones for animal driven *tahonas* was identical to those of millstone for other types of mills. Hence any millstone quarry could deliver an order for a *tahona*.

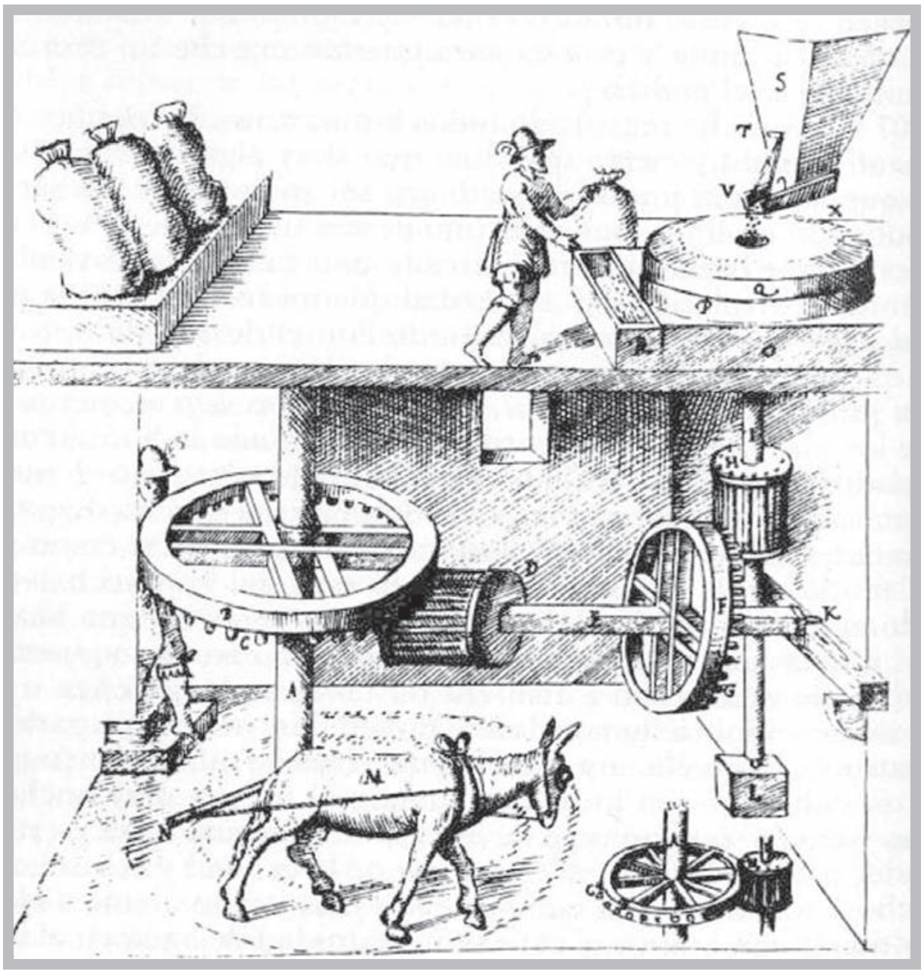


Fig. 3.23: Extract from the Codex of pseudo Juanele Turriano (approx. 1595) depicting a tahona *(animal-driven grain mill). The scene is of a sophisticated mechanism divided into an mill house (upper level with the millstones) and wheel house with the animal (lower level) (Madrid, Biblioteca Nacional, digital image from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

*Fig. 3.24: View of part of the animal-driven flour mill (*tahona*) in the castle of Calatrava la Nueva (Aldea del Rey, Ciudad Real). In spite of being in the heart of the Calatrava volcanic district, the millstones are of conglomerate (photograph left http://patrindustrialquitectonico.blogspot.com.es/2011/08/un-molino-del-siglo-xii-es-las-nueva.html; photograph right by T. Anderson).*

3.5. Watermills

3.5.1. Roman watermills

The identification of Roman watermills through fieldwork and through research in museum depositories is becoming more and more commonplace in the last years, in particular in central Europe. In France, besides the complex of Barbegal near Arles (Leveau 2006), watermills have been identified in the *villae* of Mesclans and Saint-Pierre (Brun & Borréani 1998), at Longvic near Dijon in eastern France (Jaccottey & Labaune 2010). In Switzerland, four Roman watermills have been identified: Hagendorn, Zug (Gähwiler & Speck 1991); Rödersdorf-Klein Bühl, Solothurn (Harb 2002), Avenches/En Chaplix (Castella 1994); and Avenches/Les Tourbières (D. Castella, pers. comm.). A systematic study of ancient millstones stored in Swiss collections clearly substantiated that hydraulic mills were widely distributed throughout the countryside of Roman Swiss Plateau (Anderson *et al*. 2004).

At the moment, the discoveries in France and Switzerland point to the use of the vertical water wheel. The millstones at these sites are often bell-shaped, long-distance imports of volcanic rock measuring between 55 and 90 cm in diameter (fig. 3.25). Two systems of transmitting motive power from the vertical spindle to the upper stone have been recognised. The first combines holes and grooves cut into the upper surface (in French *anille-crampons*; Castella 1994: 47, fig. 31). The second is the traditional system by means of the rynd set into slots cut at the base of the stone.

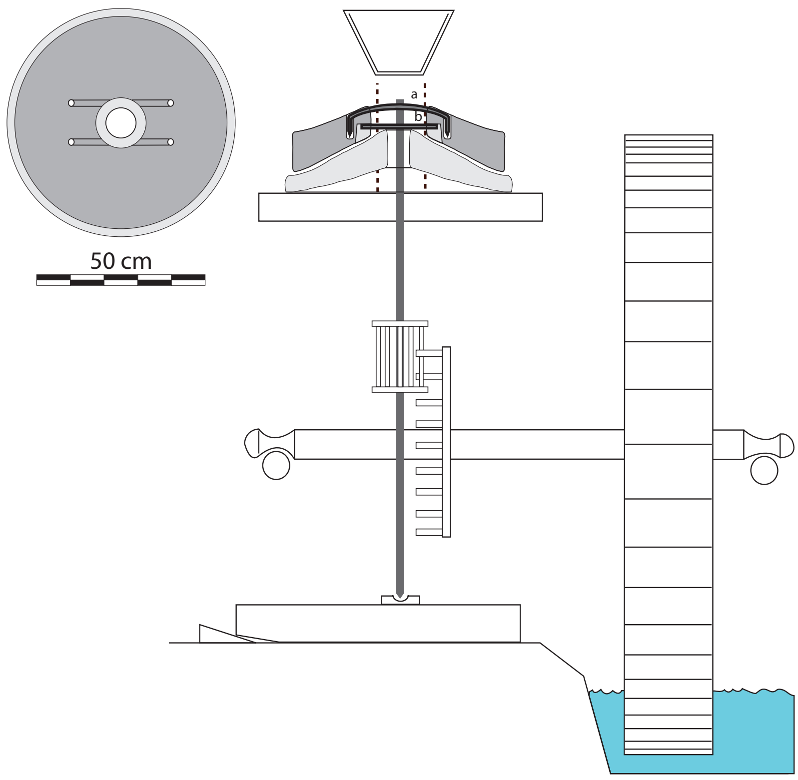


Fig. 3.25: Schematic representation of the Vitruvian vertical waterwheel. The two systems of transmission of the motive force are represented: a) "anille crampons" on the upper surface and b) rynd on the lower surface (drawing by T. Anderson based on Castella 1994).

The situation of watermills in Roman provinces of *Hispania* is far from settled. With the exception of *Conimbriga* in Portugal (Brun 1997), no Roman watermill installation or millstone has been unequivocally identified.

With the growing number of discoveries of Roman watermills elsewhere in Europe, it seems unlikely that this mill was absent in *Hispania,* so well-known for its hydraulic works (aqueducts, dams). To date, however, only one millstone, a highly vesicular, black volcanic *meta* measuring 65 cm in diameter, (fig. 3.26), conforms typologically to those of Roman watermills brought to light in France and Switzerland. This surface find, exposed at the entrance of the archaeological site of Oreto y Zuqueca (Granátula de Calatrava) near the Roman centre of *Oretum*, was presumably a part of a watermill along the nearby Jabalón River.

Consequently no Roman watermill quarry has been identified. It would be reasonable to assume that the millstone exposed at the site of Oreto y Zuqueca, in the heart of the Calatrava volcanic province, was produced in a local or regional quarry at the nearby Cerro Columba (CR-6) or at Las Herrerías (CR-2), by Bolaños de Calatrava, only 15 km to the northeast. But this remains to be confirmed.

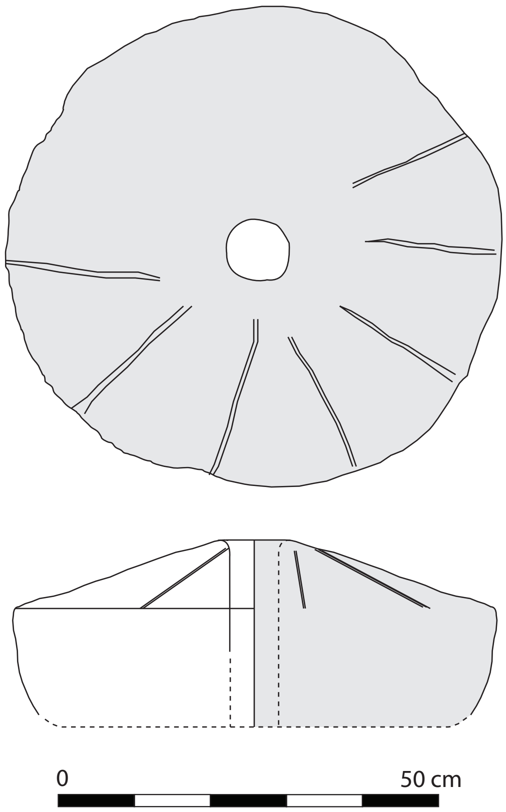


Fig. 3.26: Photograph and drawing of the lower stone at the entrance to the archaeological site of Oreto y Zuqueca (Ciudad Real). The size, morphology and lithology of this lower stone, a surface find, conforms to that of millstones found in Roman watermills (photograph and drawing: T. Anderson).

3.5.2. Medieval to Contemporary watermills

The greatest part of the millstone quarries identified in southern Spain date from the Middle Ages to the Contemporary periods and their millstones were intended for watermills. These periods, covering a span of about a millennium, are grouped into one unit because the millstones, from a morphological standpoint, are similar. The bell-shaped model from Roman times give way to flatter, discoidal model with rynd cuttings on the lower side of the upper stone. The more recent models measure for the most part between 1,00 and 1,30 m in diameter. There is nonetheless a huge gap still to be filled regarding the evolution of hydraulic millstone dimensions from Late Antiquity to Modern times. In quarries we observe a number of discoidal extractions corresponding to models between 70 and 80 cm in diameter. These early models however are not known in molinological literature.

Watermills for cereal milling in these periods were built along rivers, canals and *acequias* (irrigation ditches). For the most part, they were built with stone and comprised two stories: a lower level (wheel house), reserved for the waterwheel and gearing machinery, and the upper level (mill house), where the grinding took place (fig. 3.27).

There are two main types in our study area. *Aceñas* were mills driven with vertical waterwheels, whereas *rodeznos* were driven by horizontal water wheels. Other hydraulic grain mills, such as tide mills and boat mills, were much less common in this area and will not be described.

The development of the hydraulic milling technology in southern Spain has been the subject of much molinological research (Reyes Mesa 2000; 2006; Córdoba de la Llave 1988, among others). The following descriptions, therefore, are no more than superficial portraits of the more common types of hydraulic mills in our study area.

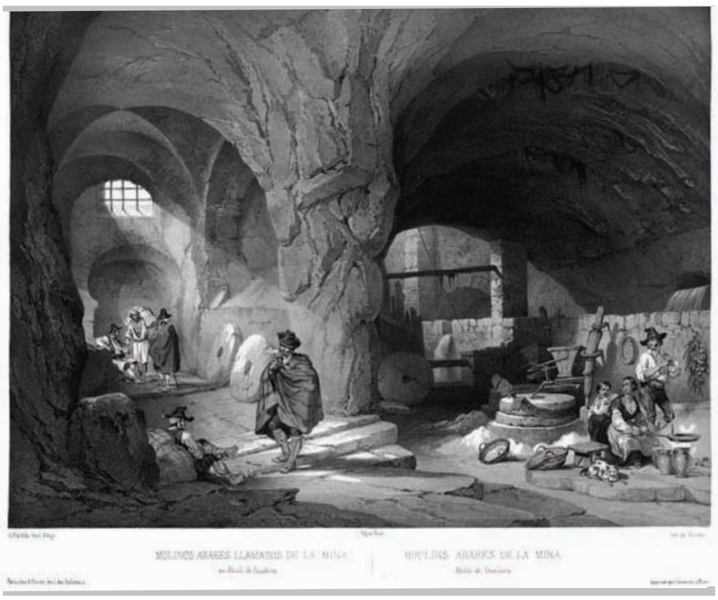


Fig. 3.27-1: Engraving from 1842 entitled Molinos Árabes de la Mina en Alcalá de Guadaira by Genaro Pérez de Villaamil (Museo del Romanticismo, Seville). The scene is the mill house of a subterranean watermill under the town of Alcalá de Guadaira (Seville). The millstones of these mills were powered by horizontal wheels pushed water harnessed from natural wells. To the right are two mills with their respective hoppers and a propped up millstone. To the left are two millstones propped against the wall of a different mill. The scene seems to reflect more the situation of the middle of the 19th century than a scene dating to the Islamic domination (from http://sevillalegendaria.blogspot.com.es/2013/05/los-canos-de-carmona-agua-e-historia.html).

3.5.2.1. *Aceñas* (vertical waterwheel mills)

The term *aceña* derives from the Arabic term for "elevator", and in the context of grain mill, refers to the vertical waterwheel set directly in the flow of the river or canal to drive one or more millstones. The force was transmitted by means of gears, converting the vertical motion of the waterwheel into the horizontal rotation of the millstones (fig. 3.28). *Aceñas* are the direct heirs of the Roman "Vitruvian" watermill.

In the south of Spain, these mills were restricted to certain watercourses. In the Province of Córdoba, for example, *aceñas* were known during the Islamic domination to have been constructed on the larger Guadalquivir and Guadajoz Rivers (Córdoba de la Llave 1988: 835).

In fact, the most celebrated group of *aceñas* in our study area is the chain of 11 mills at Córdoba along the Guadalquivir River. These mills, dating from the Middle Ages, have undergone many transformations over the years (Montero 2008). Some are represented in an engraving by the Flemish artist Anton Van den Wyngaerde dating to 1567 (fig. 3.29). In earlier times they

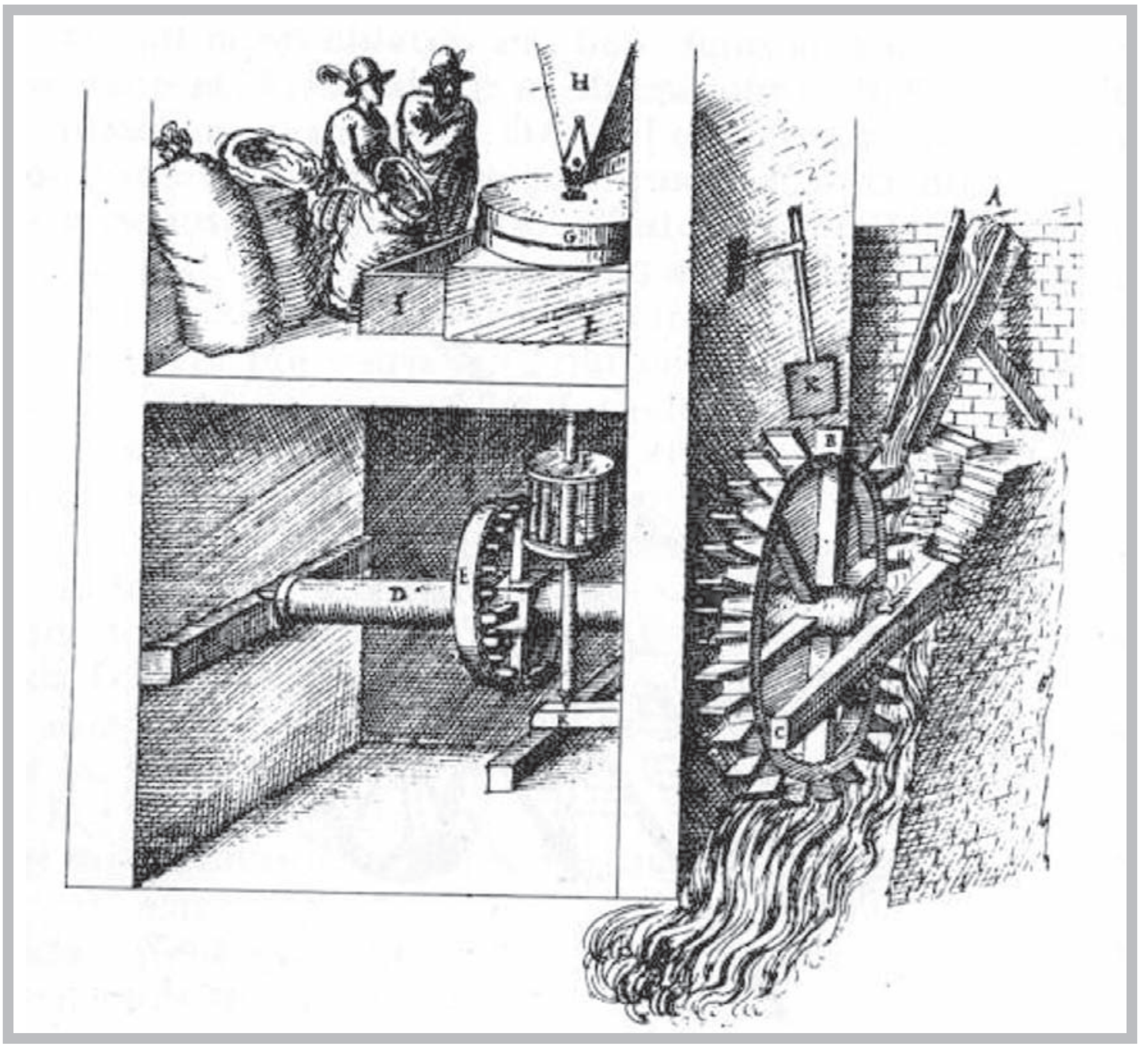


Fig. 3.28: Extract from the Codex of pseudo Juanele Turriano (approx. 1595) depicting an aceña *(vertical wheel grain mill). The structure is divided into a mill house (upper level with the millstones) and wheel house (lower level) (Madrid, Biblioteca Nacional, digital image from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

were equipped with sandstone millstones from local quarries, such as that of Albaida (CO-7) (Córdoba de la Llave 2003: 305). At a certain point in the last few centuries, some began to import the higher quality *rosso ammonitico* millstones from quarries in the Cabra area (CO-1; CO-2), about 85 km to the southeast (Montero 2008).

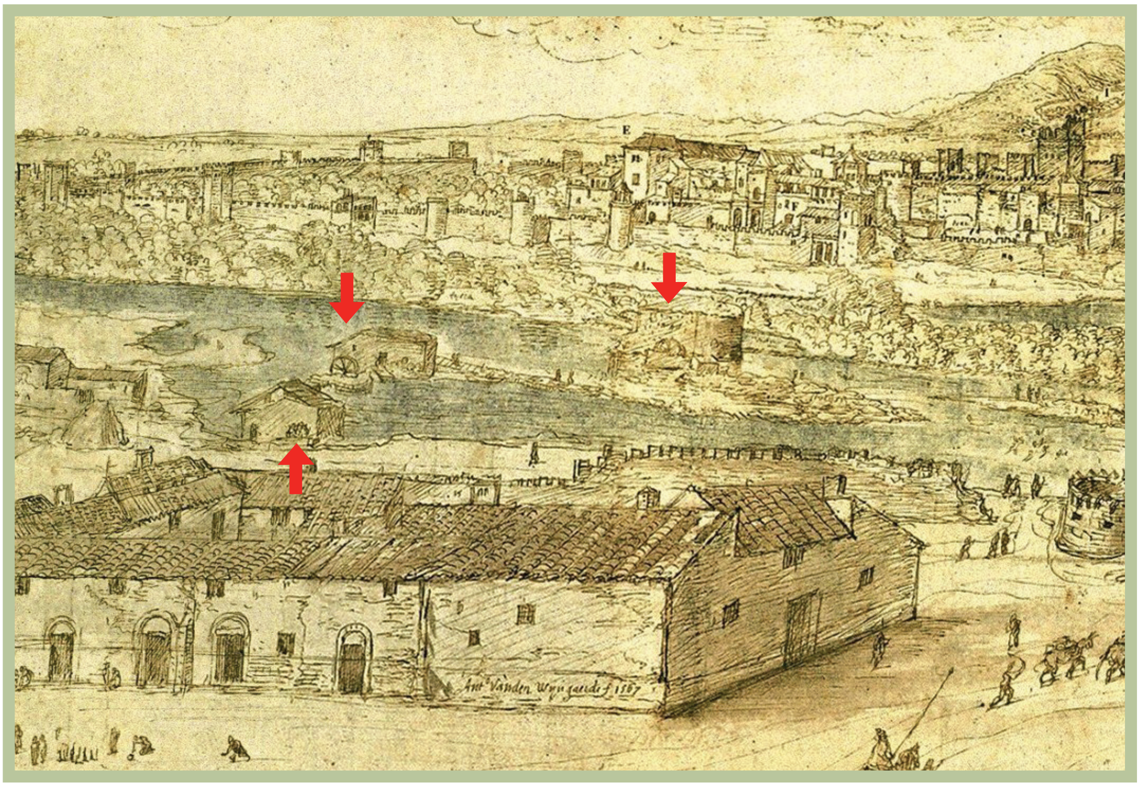


Fig. 3.29: Extract from an engraving by the Flemish artist Van den Wyngaerde (1567) with a view of the city of Córdoba. The arrows point to the waterwheels of the aceñas *in the Guadalquivir River (original illustration in the Victoria and Albert Museum of London).*

3.5.2.2. *Rodeznos* (horizontal waterwheel mills)

The *rodezno* mill (from the Latin *rota,* meaning "wheel") was equipped with a horizontal waterwheel (fig. 3.30). This mill type is better adapted to the shallow or fluctuating sources of water common to the south of Spain (Reyes Mesa 2006: 213). The transmission of the driving force from the wheel to the stones was either direct, through the shaft (meaning the millstones turned at the same rate as the turbine), or indirect, by means of a gearing system (similar to that vertical wheel mills) allowing the miller to adjust the velocity of the millstones. Water was directed to the wheel either by means of a channel (*molino de rampa*), inclined at an angle of about 45º, or by a more complex feature that guided the water through a penstock (*molino de cubo*), usually a vertical cylindrical feature (like a well) several metres high and about a metre in diameter. This system permitted the jet of water it released at its base to gain strength and, by impacting the paddles, drive the wheel (Reyes Mesa 2006: 193-201).

The *rodezno*, in our study area, is by far the most common type of grain mill. As the city of Córdoba with the deep and wide Guadalquivir River epitomizes the use of mills with vertical waterwheels, the city of Granada, with its shallow rivers at the foot of the Sierra Nevada mountains, typifies the use of the *rodezno* (fig. 3.31). In a recent study of more than 700 mills of Granada and its province, all but two applied the *rodezno* technology (Reyes Mesa 2006: 213).

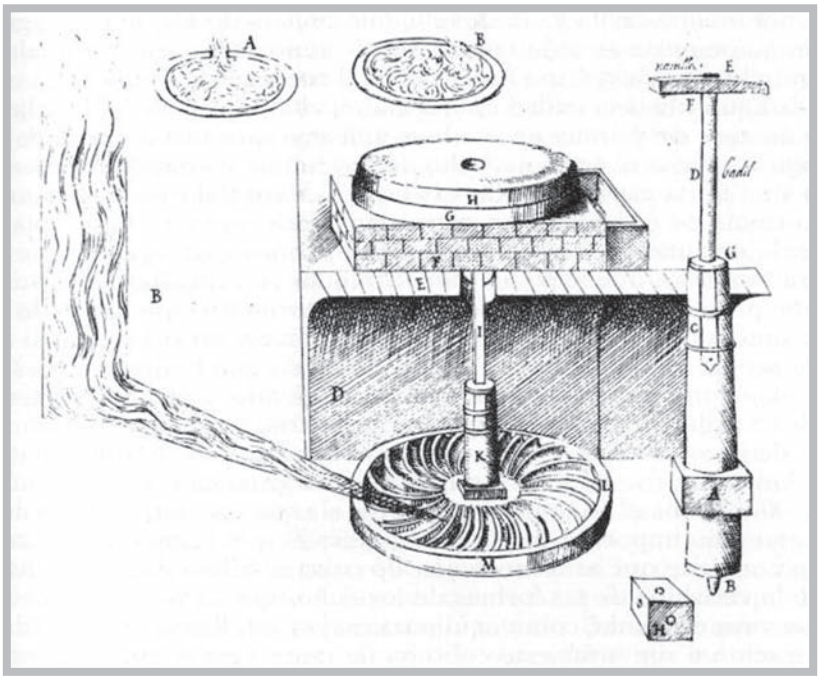


Fig. 3.30: Extract from the Codex of pseudo Juanele Turriano (approx. 1595) depicting a rodezno *(horizontal wheel grain mill) (Madrid, Biblioteca Nacional, digital image from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

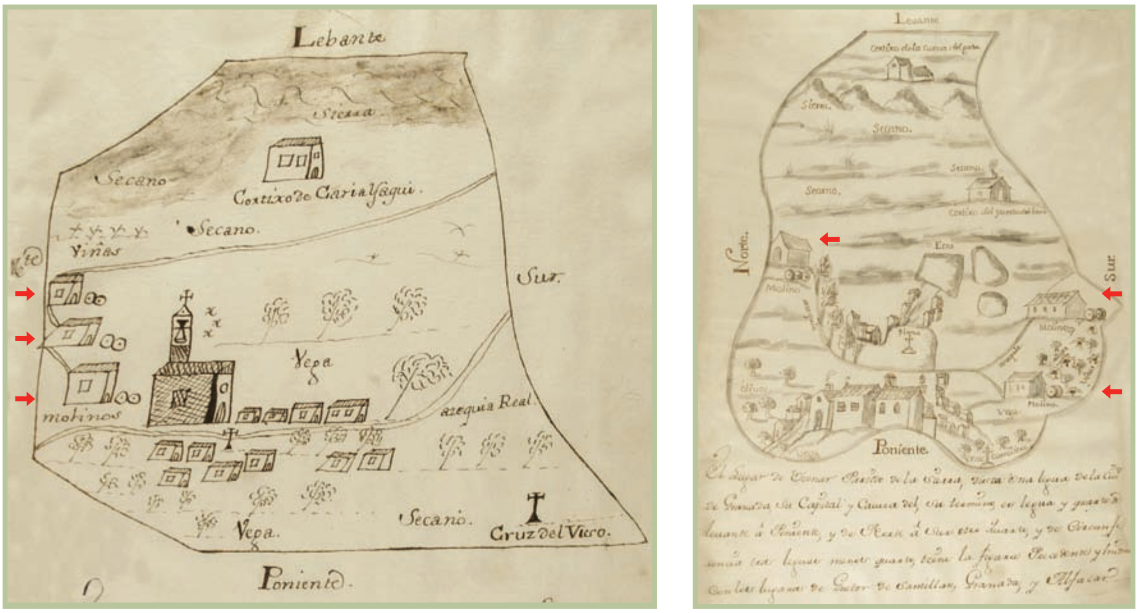


Fig. 3.31: Drawings from the Catastro del Marqués de Ensenada (1750-1754) of the towns of Nivar and Viznar (Province of Granada) with the location of the rodezno *watermills. These drawings supplement the answers of a questionnaire and illustrate the principal features of the towns such as mills, churches, houses, surrounding farms, irrigation ditches (*acequias*) and landmarks (crosses) (from El Catastro del Marqués de la Ensenada en el Antiguo Reino de Granada, Instrumentos de Descripción, Archivos 16, Consejería de Cultura, Junta de Andalucía (CD format), no date.*

3.6. Windmills

Contrary to the impression drawn from the tale of Don Quixote, windmills represent only a modest fraction of the grain mills in Spain. K. Lizarralde only records 676 cases (about 3%) of a total of 25,000 from the Madoz dictionary (Lizarralde 2010). (Curiously, according to Lizaralde's numbers, the lesser-known animal-driven *tahonas*, at 1,476, nearly doubles that of windmills). A second quantification of old mills undertaken in the province of Granada registers only two windmills in a total of 542 (Reyes Mesa 2006: 213).

Windmills in Spain, for the most part, were grouped in certain areas where water was in short supply or could not be easily harnessed. Don Quixote's La Mancha region, spread over several provinces in central Spain, is the location of the most celebrated group. These "giants" with whitewashed bodies capped with black cones can still be seen in a number of towns: Alcázar de San Juan (fig. 3.32); Campo de Criptana and Valdepeñas (Ciudad Real); Consuegra (Toledo), Villarobledo Albacete); and Mota del Cuervo (Cuenca). The Flemish 16th century artist Anton Van den Wyngaerde, at the service of King Phillip II, depicted a group on the horizon outside the town of Belmonte (Cuenca) (fig. 3.33). The vanes of this "Manchego" type, normally four, are rectangular, made of wooden slats covered with canvas.

The second concentration of windmills in Spain is in the southeast of the Peninsula, from the south of Alicante (Torrevieja) (fig. 3.34), through the Campos de Cartagena of Murcia and the Campos of Níjar in Almería (fig. 3.35). These are some of the driest regions in Spain. The vanes of these windmills differ from their Manchego counterparts in that they are triangular sails (Rojas & Amezcua-Ogáyar 2005).

Fig. 3.32: View of the windmills outside the city of Alcázar de San Juan (Ciudad Real). Photograph by T. Anderson.

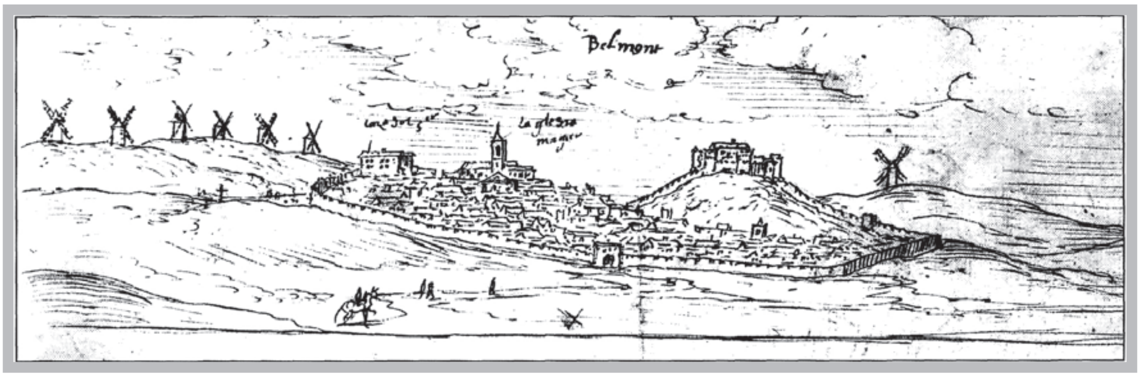


Fig. 3.33: Drawing of the windmills of Belmonte (Cuenca) by Van de Wyngaerde (1563). The Flemish artist was at the service of King Phillip II. The work is in the Victoria and Albert Museum, London (from Ibáñez 2003: 75).

Windmills of both the Mancha and the southeast share a cylindrical tower built of stone topped by a cap of wood, holding the gearing system, that could be pivoted to face the wind by means of a tail pole. The origin and the precise date of the introduction of this technology (sometime during the Islamic domination) is still a question of debate (Rojas & Amezcua-Ogáyar 2005) and beyond the scope of this work.

We have no evidence in our study area that millstones destined for windmills differed in any sense from those for watermills (fig. 3.36). Madoz, in his comments of the production of El Berrueco (CA-8), lumps production of millstones for watermills and windmills in the same lot (albeit different from *tahonas*) (Madoz 1847, Vol. 6: 525), suggesting that millstones for water and windmills were identical. There is only one quarry site, Pedrizas de Piédrola (CR-4), on the outskirts of Alcázar de San Juan, the location of a large cluster of windmills (cf. fig. 3.32), that can be related directly to windmills millstone production. We, unfortunately, have little specific data about that site.

Fig. 3.34: Photograph by Jean Dableda of the town of Torrevieja, Alicante in the late 19th century. Four windmills can be seen on the horizon (photograph from the blog of Franciso Rebollo Ortega, http://franciscorebollo.blogspot.com.es/2011_09_01_archive.html).

Fig. 3.35: Examples of windmills in southeastern Spain driven by vanes with triangular sails (left photograph of the Molino Viejo de Zabala, Cartagena, Murcia (photograph left by Torres Ros, http://www.forocartagena.com/t800-molinos-de-viento-y-arquitectura-del-campo-de-cartagena; photograph right Cabo de Gata, Nijar, Almería by T. Anderson).

Fig. 3.36: Examples of millstones in the Cabo de Gata of the province of Almería (Isleta del Moro and Las Negras) from nearby windmills. a) Coarse sandstone b) porous limestone. From the petrographical and morphological point of view, these millstones shown no differences with those produced for watermills.

4. MILLSTONE QUARRY GEOLOGY

4.1. Generalities

The following text (in italics) is a sketch of the geology of the southern half of the Iberian Peninsula penned by Jane H. Scarrow of the Geology Department of the University of Granada for an article about millstone quarries in the south of Spain (Anderson & Scarrow 2011). It was published in the proceedings of the *Bread for the People* colloquium held in Rome in 2008. The original text was modified and extended from the introductory chapter of *La Geología de España* (Vera 2004). In the original article, the illustrations appeared in black and white. A second, slightly modified version of this text was submitted recently to the proceedings of the colloquium *Through the Eye of a Millstone* held in Bergen, Norway (2011) in an article about rotary querns and their production sites in the south of Spain (Anderson *et al.* Submitted).

The geology of the Iberian Peninsula is dominated by the high central Iberian Massif. After considerable debate, this Massif, that covers most of the western half of the Peninsula, was divided into six main zones. Broadly from north to south these zones are as follows: Cantabrian (fig. 4.1, sector A); West Asturian-Leonese (fig. 4.1 sector B); Galicia Tras-Os-Montes (fig. 4.1, sector C); Central Iberian (fig. 4.1, sector D); Ossa-Morena (fig. 4.1, sector E) and South Portuguese (fig. 4.1, sector F). The central region has an average elevation of 660 m and is bordered to the north by the basin of the Duero River, to the northeast by the Ebro River and, broadly, to the south by the Guadalquivir Valley. Lying beyond these hydrographic confines are the Cantabrian Cordillera in the north, the Pyrenees in the east and the Bétic Range in the south.

This study of millstone quarries basically concerns the region to the south of the River Tagus that flows east to west, cutting the Peninsula into two roughly equal parts. Thus, rocks exploited for the millstone production considered here include: the Precambrian to, predominantly, Palaeozoic granite-gneiss-schist igneous and metamorphic crystalline rocks of the three most southerly zones of the Iberian Massif (Central Iberian, Ossa-Morena, and South Portuguese); the Mesozoic-to-Cenozoic limestone-sandstone-conglomerate sedimentary rocks of the southerly basins and the Bétic Range; and the Cenozoic volcanic rocks of the recent meridional magmatic activity.

The Central Iberian Zone of the Iberian Massif, encompassing large areas of Extremadura, Castilla-La Mancha and Madrid (fig. 4.1, sector D), comprises Proterozoic and early Palaeozoic metasediments and orthogneisses, extensive Lower Ordovician 'Armorican' quartzites and widespread

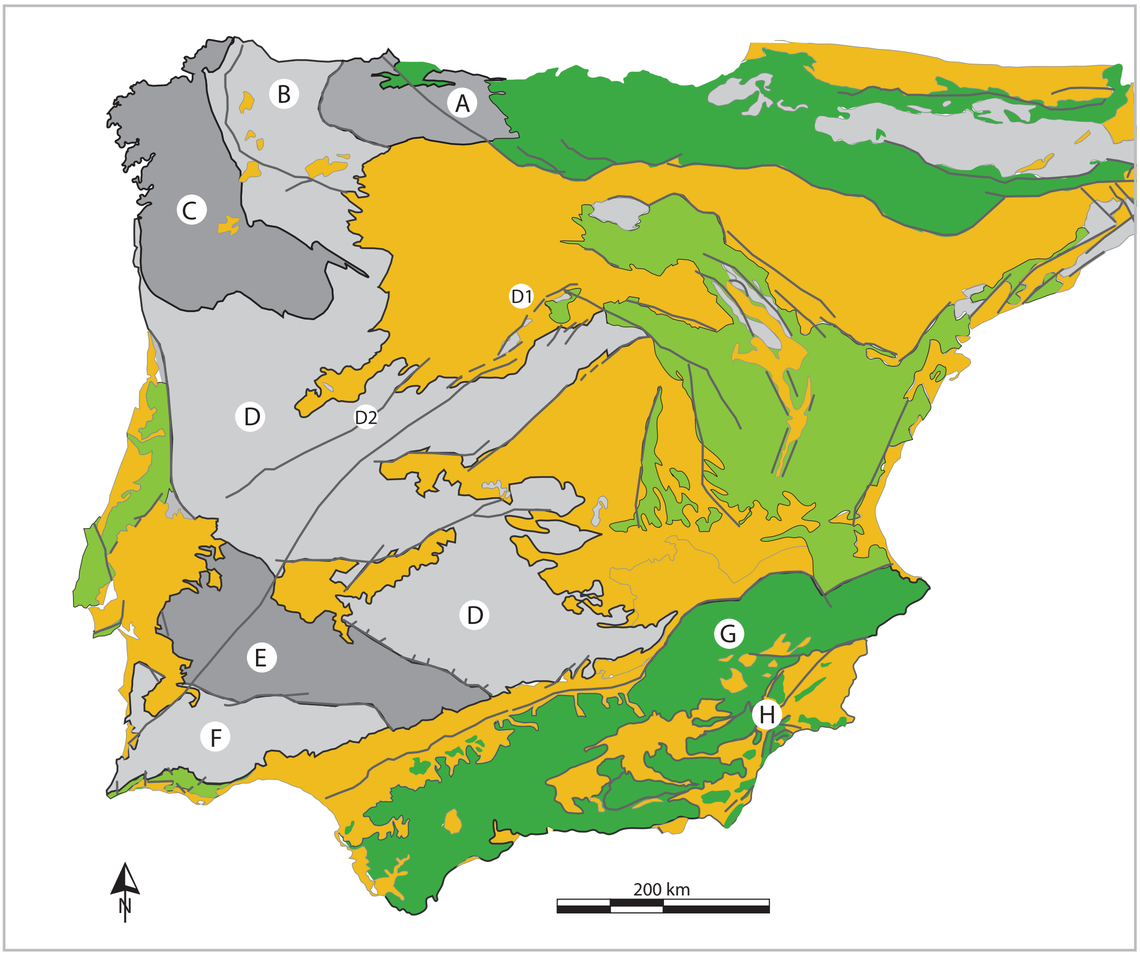


Fig. 4.1. Map of the principal geological zones of Iberia. Letters, also mentioned in the text, refer to the following regions. A. Cantabrian Zone; B. Western-Asturian Leonian Zone; C. Galicia Tras-Os-Montes Zone; D. Central Iberian Zone, D1. 'Ollo de Sapo' domain, D2. Greywacke-Schist Complex domain; E. Ossa Morena Zone; F. South Portuguese Zone; G. Bétic range External Zone; H. Bétic range Internal Zone (after Farias et al. 1987). A black and white version of this map appeared in Anderson & Scarrow 2011: 261.

Carboniferous granitoids. The Zone is divided into two domains mainly on the basis of the rocks underlying the quartzite. In the north, the 'Ollo de Sapo' domain pre-Ordovician rocks are potash feldspar augen orthogneisses, high grade regional metamorphic rocks and Variscan syn-tectonic granites (fig. 4.1, sector D1). In the south, the Greywacke-Schist Complex domain pre-Ordovician rocks are schists and greywackes, the metamorphic rocks are low grade and the granitoids are syn- and post-orogenic (fig. 4.1, sector D2).

The Ossa-Morena Zone occupying parts of the provinces of Huelva and Seville (fig. 4.1, sector E) is made up of Upper Proterozoic to Carboniferous rocks. Oceanic basic igneous rocks crop out at the northern contact with the Central Iberian Zone and the southern contact with the South Portuguese Zone. The main lithologies in this region are low grade metamorphic rocks and granitoids of varying ages including Vendian, Cambrian and Carboniferous synand post-orogenic intrusions.

The South Portuguese Zone (fig. 4.1, sector F), the most meridional division of the Iberian Massif (in the Huelva province), is composed of Devonian to Carboniferous volcano-sedimentary, igneous and low-grade metamorphic rocks that, in places, are overlain by Permian sediments.

The Bétic range in the south and southeast of the Iberian Peninsula (fig. 4.2), from Huelva all the way to Alicante, forms the most westerly sector of the Alpine orogen that borders the northern and southern margins of the Mediterranean. The Bétic cordillera is divided into two main zones, which were two separate microplates through the Mesozoic and Cenozoic: the External Zone (South Iberian paleomargin) and the Internal Zone (Alborán Domain fragment of the Mesomediterranean plate). The External Zone, to the north (fig. 4,1, sector G), comprises Triassic to Miocene continental margin sedimentary rocks. This zone is further subdivided into the northerly Prebétic relatively undeformed shallow marine sediments and the more strongly deformed southerly Subbétic lower Jurassic pelagic sediments and submarine volcanic rocks. The Internal Zone, to the south (cf. fig. 4.1, sector H), is made up of a stack of tectonic units, from base to top: the Nevado-Filábride Complex, the Alpujárride Complex and the Maláguide Complex. In contrast to the External Zone, the pre-Mesozoic basement of this region was displaced together with the Triassic to lower Miocene cover rocks. The basement part of the two lower units preserves traces of pre-Alpine deformation, magmatism and metamorphism, which in the Alpujárride Complex includes continental crust and subcontinental upper mantle. Both the basement and cover of all three units were affected by complex Alpine metamorphism. Throughout part of the Mesozoic through to the mid-Paleogene, turbidites were deposited in a narrow ocean basin that existed between the External Iberian plate and the Internal zone Mesomediterranean plate. These marine sediments are preserved in the Campo de Gibraltar Complex.

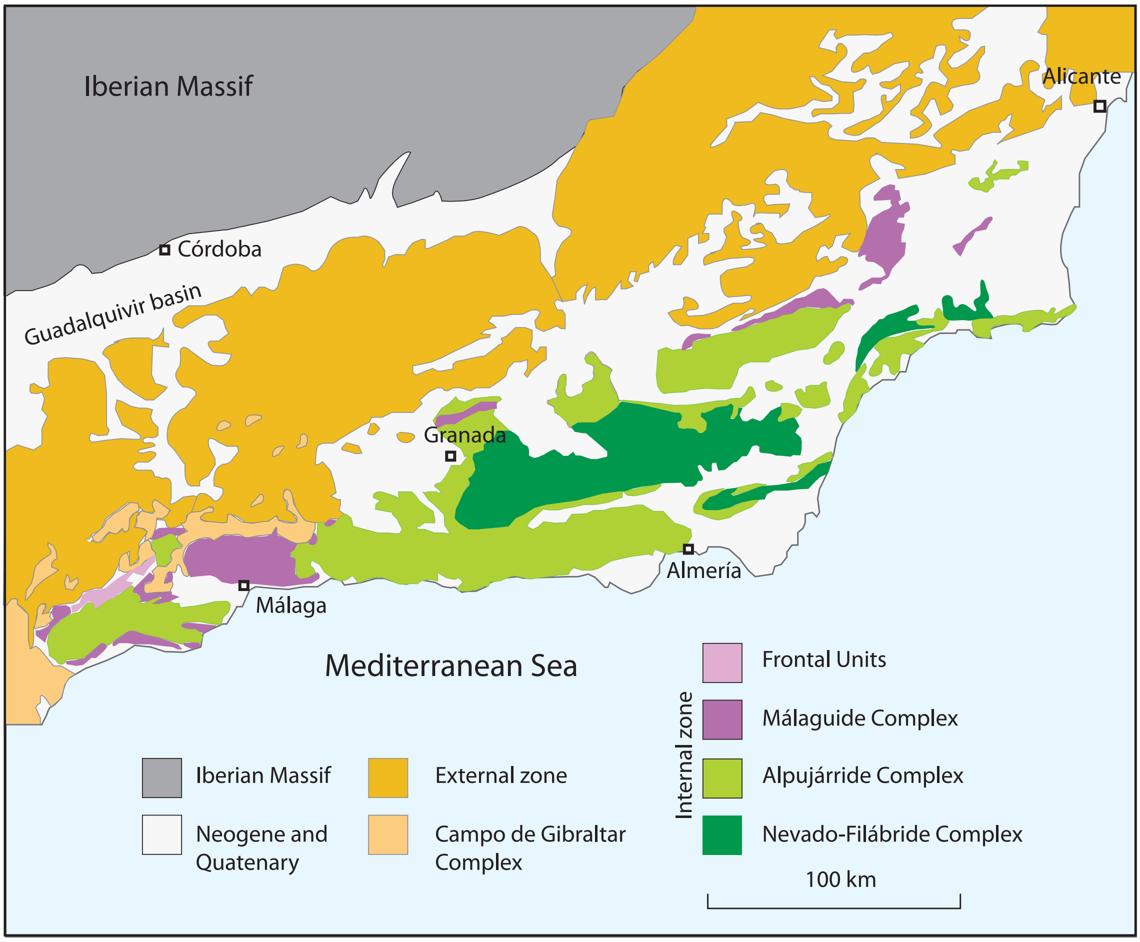


Fig. 4.2: Detailed map of the principal geological formations of the Bétic range (after Martín Algarra 2004). A black and white version of this map appeared in Anderson & Scarrow 2011: 261.

Cenozoic volcanic rocks crop out in four regions throughout the Peninsula: Gerona, Gulf of Valencia, Calatrava and Almería-Murcia. The last two of these are of interest in the current work and include the oldest volcanism, Aquitanian, in Cabo de Gata (Almería) and some of the youngest, Holocene, in the Campos de Calatrava (fig. 4.3). The Calatrava rocks are basic alkaline and carbonatites. In the Almería-Murcia region, the igneous rocks are more varied including calc-alkaline to alkaline compositions.

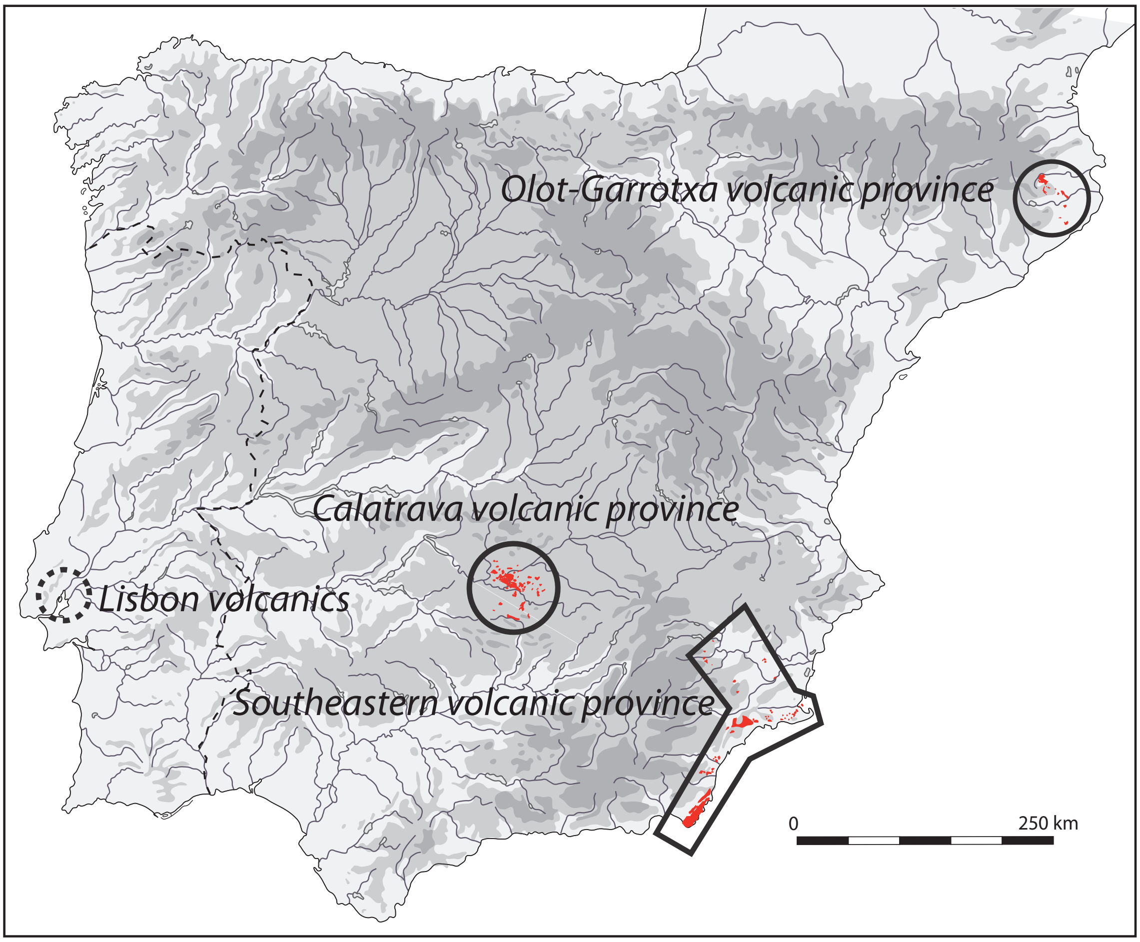


Fig. 4.3: Map of the volcanic districts in the Iberian Peninsula. The red areas correspond to Neogene Quaternary volcanism (based on the Geological Map of Spain, 1.1.000.000, IGME 1994). The Olot-Garrotxa volcanic district in Girona (Catalonia) is known as millstone production centre since the 1980s (Williams-Thorpe & Thorpe 1987; Williams-Thorpe 1988). Millstone production has been only identified through our work in recent years in the Calatrava and Southeastern volcanic provinces. The drawings of the volcanic districts are based on geological maps (IGME). The Southeastern volcanic province is updated from Cambeses 2010.

4.2. Millstone rocks

Millstone makers of the past were not geologists. They nevertheless, displayed a keen, intuitive sense of the qualities of rocks. The principal properties desired were those of hardness and abrasiveness. The rock had to either be porous or contain inclusions or crystals that could bite the grains while, at the same time, release as little particles of grit as possible, a detriment to the teeth (and ultimately the health) of the consumer. Some millstones, to ensure a higher quality of grinding, required dressing either by pecking or carving furrows in a wide array of patterns.

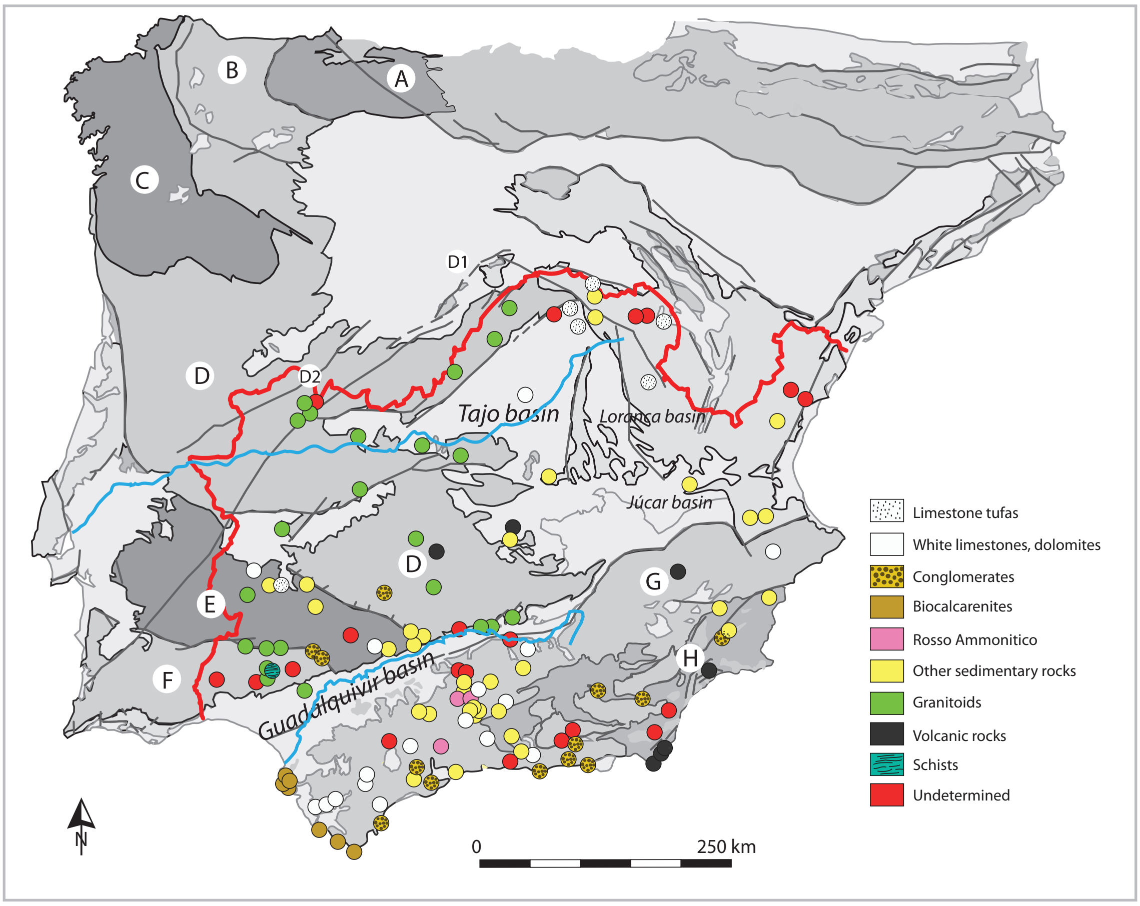


Fig. 4.4: Distribution map of the millstone quarries by rock type. The base is the geological map (see fig: 4.1). The red line indicates the border of the study area.

Based on our observations in quarries, on geological texts (both old and new), on data from geological maps (*IGME*) and of millstones in museum depositories, we have established 9 basic rock types that were exploited for the millstone production. Their spread throughout the southern Iberian landscape is represented in fig 4.4. Half of the rocks are of sedimentary origin. The remaining are igneous, notably volcanic, or in one case (schist) metamorphic.

The portraits of each of the rock types were brought together, for the most part, from dictionaries and the following geological websites: http://geology.com/dictionary/glossary-t.shtml; http://college.cengage.com/geology/resources/geologylink/glossary.html; http://www.webref.org/geology/l.htm. When relevant, we have completed the descriptions with our own personal observations.

4.2.1. Sedimentary millstone rocks

4.2.1.1. Limestone tufas or travertines

These are cream-coloured, highly porous rocks that are formed by calcium carbonate precipitation (springs, caves, or streams carrying large amounts of carbonate solution). It is a rock that must have been relatively easy to carve. Once dry it probably became very hard. This rock was possibly exploited both in the form of quarries of the southern mountains of Córdoba in

Protohistory, in particular in the area of Almedinilla, Córdoba (CO-15). Several Contemporary quarries are reported in the northern sector of our study area, notably at the town of Tobes (Guadalajara) (GUA-5), whose name derives from the name of the rock (*toba*).

4.2.1.2. White limestones and dolomites

These are fine, hard, white (or slightly grey) sedimentary rocks, composed mainly of calcium carbonate or dolomite. They sometimes present themselves in the form of massive layers that allow deep quarry exploitation such as at Moclín, Granada (GR-1). They also are in the form of layers around a metre thick, such as is the case of Alhama de Granada (GR-6), Lachar by Jimena (J-2) and Colmenar de Oreja (M-2). They appear as well in the form of small, highly eroded surface outcrops (karsts) exploited individually or in small groups such as the Camino del Calvario quarry near Loja (GR-3) .

4.2.1.3. Pebble conglomerates

These detrital rocks possess rounded clasts of several lithologies, generally measuring a few centimetres in length (up to 10 cm), bounded by a fine cement. These were exploited both in the form of surface blocks and true extractive quarries. Layers of this type of rock, although not thick (approximately about 1 m), extend over large surfaces and were exploited in true extractive shallow quarries such as at the Puerto de la Cadena in Murcia (MU-1), Rambla Honda (AL-3) or Playa de Carchuna (GR-9). They were also exploited by means of detaching angular blocks, such as the trench quarry at the Cantera de la Rambla near Caniles, Granada (GR-11).

4.2.1.4. Biocalcarenites

Biocalcarenite is a yellowish, highly porous sandstone composed predominantly of marine shells. This type refers, in particular, to a series of outcrops along the Bay of Cádiz that are known commonly known as *ostionera* (meaning oyster) due to the shell inclusions. The outcrops, ranging from fine-grained to very coarse-grained and spread over a corridor about 100 km long between the cities of Tarifa and Chipiona, were exploited for querns and millstones in several extractive quarries along the Atlantic coastline of the Province of Cádiz.

4.2.1.5. *Rosso ammonitico* limestones

These are fine, hard, pink limestones including large fossils, notably ammonites. Like the white limestones or dolomites, outcrops of this rock present themselves both in the form of massive formations exploited by extractive quarries, such as in Cabra, Córdoba (CO-1), or in the form of small, highly eroded surface outcrops or karsts such as at El Torcal in Málaga (MA-1).

4.2.1.6. Other sedimentary rocks

This group corresponds to quarries in areas dominated by sedimentary rocks that, although identified (by old texts, for example), have not been pinpointed on a map and therefore do not benefit from a precise geological description.

4.2.2. Metamorphic millstone rock (schists)

Schist, the only metamorphic rock known to have been used for millstones in our study area, is coarse-grained, highly foliated and contains particles of mica. Characterized by flat, parallel slabs that split with ease, this rock contains crystals, such as garnets or staurolites, that play an important role in the grinding process. Schists were exploited massively for querns and millstones in Norway, notably at Hyllestad and Selbu (Grenne *et al.* 2008). In Roman Switzerland they were an alternative, in the form erratic blocks, to *grès coquillier* quarries (Anderson *et al*. 2003: 64-67). In the southeast of the Iberian Peninsula, many Prehistoric and Protohistoric saddle querns are fashioned from this material. Quarry workings are minor. Only one exploitation is known at El Campillo Province of Huelva (HU-1).

4.2.3. Igneous rocks

4.2.3.1. Granitoids

The term granitoid covers a range of very hard, granular, crystalline rocks mainly of quartz, mica and feldspar. The colour of these millstones is mostly white but can veer to the pink. Often called "*roca berroqueña*", it presents itself in the form of surface blocks, small outcrops exploited individually or in small groups, or massive extensions exploited in large and deep pit quarries such as those around the town of Gerena in the Province of Seville (SE-7).

4.2.3.2. Volcanic rocks

These comprise a range of black, grey, or reddish-purple vesicular rocks. Rotary querns and man or animal-driven mills were highly prized in Roman times, exploited in quarries in the the two volcanic provinces of in our study area: 1) the Southeastern Spanish Volcanic district, spread through the Provinces of Almería, Murcia and part of Albacete (fig. 4.5); and 2) thevast Campo de Calatrava district in the Province of Ciudad Real (fig. 4.6). Although they can be identified as volcanic by the trained eye, painting their precise portrait (rhyolites, dacites, basalts, lamproites, melelinites) requires petrographical and geochemical analyses.

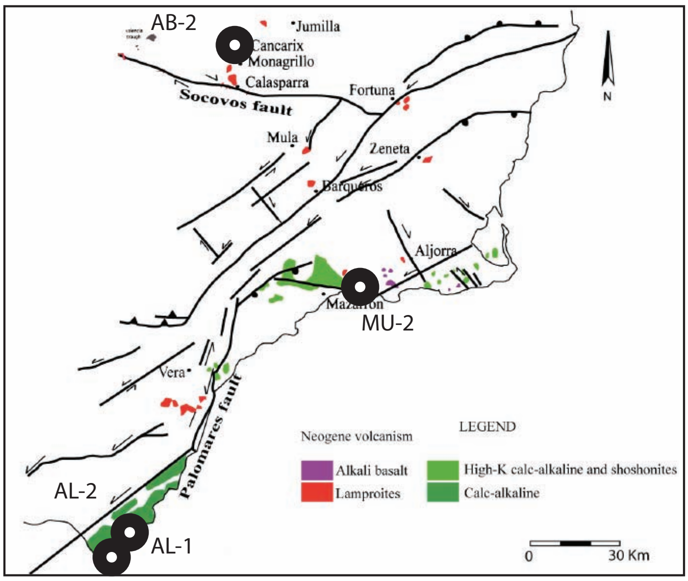


Fig. 4.5: Detail of the SE Spain volcanic district with the location of the reputed Roman quern and millstone quarries (adapted from Cambeses 2010: 8, fig. 1.3).

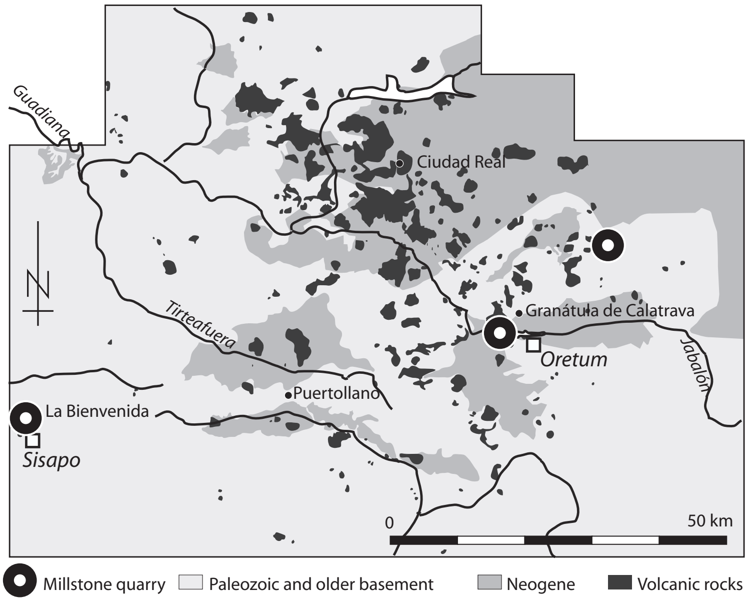


Fig. 4.6: Detail of the Campo de Calatrava volcanic district with the position of the Roman quern and millstone quarries (adapted from Anderson et al. *2011: 158, fig. 9).*

4.2. The spread of millstone quarries

The spread of millstone quarries throughout the landscape of southern Spain, in contrast to commercial distribution of their products (see chap. 12), shows that they were not distributed equally throughout the landscape. Quaternary and soft Tertiary deposits, usually too soft for millstones, were avoided. This could explains the lower number of sites along the Guadalquivir Basin in the south, and in the Tagus, Loranca and Zúcar basins in central-eastern Spain (J. H. Scarrow, pers. comm.).

The inner mountainous zones, due to their accessibility, were also apparently not exploited. This explains the empty areas in large sectors of the Bétic Range, in particular in the higher ranges of the Sierra Bermeja of Málaga, Sierra Nevada straddling Granada and Almería and the Sierra de Cazorla in Jaén. There are also no sites deep into the Guadarrama range to the northwest of Madrid. The site of Los Molares (CU-1) near Portilla in at 1350 m, in the Sierra de las Majadas (Cuenca), is the highest quarry identified in our study area.

5. MILLSTONE QUARRIES:

TERMINOLOGY, TOPOGRAPHY, TECHNIQUES

5.1. Terminology

The general terminology (fig. 5.1) used to describe the features of millstone quarries is, for the most part, borrowed from traditional building stone quarries. Other terms are adapted to the specific features inherent to millstone production, especially in the case of exploitations where cylindrical extractions were scored directly from bedrock leaving quarry faces with an appearance completely different than that of tradition building stone quarries.

The *overburden* is a combination of topsoil (humus, sands, silts, etc.) and "unhealthy", brittle rock overlaying the layer of "healthy" rock desired for millstone production. The *quarry face* is the plane (most often vertical) of rock exposed after extraction into the rock mass. The height of the face varies, depending on the number of *extractions*. Quarry faces resulting from block extraction, following natural fissures, are most often *planar*. Cylindrical extractions scored directly from bedrock by means of *trenching* yield *circular hollows*. Multiple superimposed circular extractions, like "stacks of coins", result in high *vertical tubular* faces. Los Guillares, Padul (GR-7), with up to six levels of horizontal extraction, is a good example.

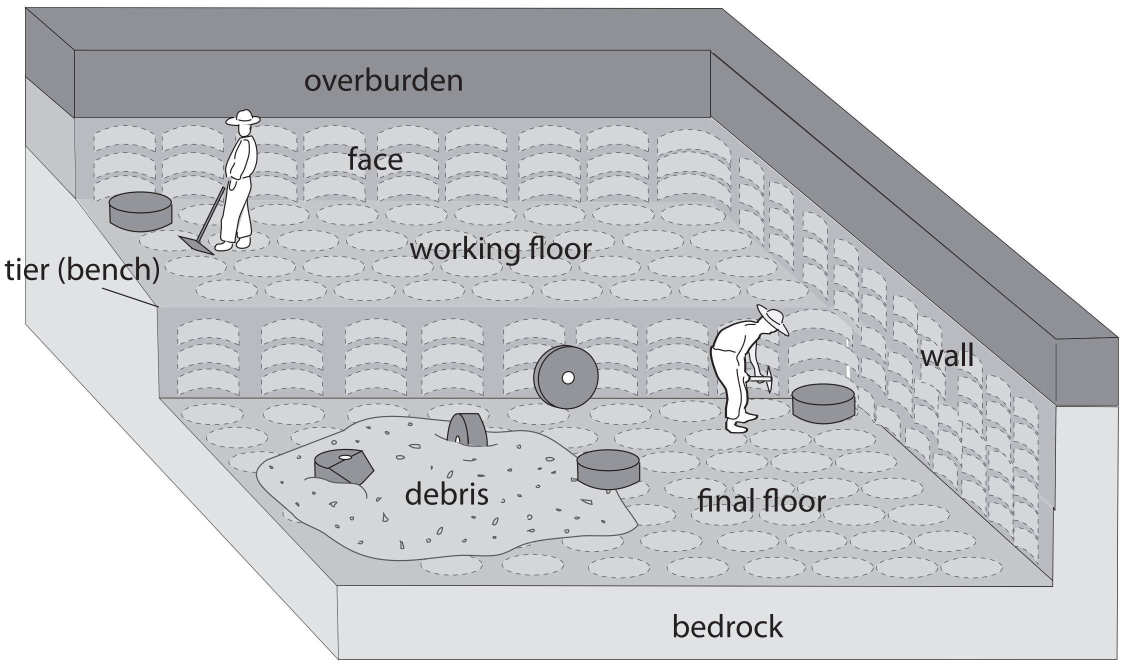


Fig. 5.1: Schema illustrating the terminology related to millstone quarries (drawing by T. Anderson).

Multiple vertical (or subvertical) extractions with a linear, horizontal forward progression into the heart of the bedrock, an extraction technique unknown in Spain at the moment but identified in the arkose subterranean quarries of the Mont Vouan in France (Belmont, unpublished), results in long *horizontal tubes* on the quarry *ceiling*.

The base of the quarry is the *floor,* a feature that is often covered with the *tool marks* resulting from the *splitting* of the cylinders. Floors, after the abandon of the sites, are often *backfilled* with *working debris*, so it is rare to be able to observe the floor tool marks to determine the splitting techniques applied to *detach* the cylinders from the rock mass. Certain quarries have several floor levels forming steps separated by *tiers* or *benches*. These differences of level permitted millstone makers to exploit more than one level of rock simultaneously. Tiers intended for exploitation are defined as *working floors*. The deepest floor of the quarry is the *final floor*.

Millstone extraction produces a great volume of debris or *spoil* that can be stored in round or oval *mounds,* or *heaps* or in elongated *cordons* away from the working area. It is difficult (at times impossible) to distinguish between the debris resulting from the *extraction phase*, and debris resulting from *fashioning phase*. Broken *roughouts* and cylindrical *blanks* are often found discarded among the debris. These are essential artefacts that help determine the *typology* and *morphology* of the product made a site.

5.2. The topography of millstone quarries

Millstone quarries are found at several natural topographical features (Walton 2004, chapt. 4) (fig. 5.2-5.3). Most often they are located on the slopes of mountains, hills or hillocks (fig. 5.2a) or along the top of ridges or cliffs (fig. 5.2b), where bedrock has been exposed by erosion. They are also found where bedrock has been exposed by permanent or periodical passage of water, such as streambeds, riverbeds, ravines and torrents. In these cases quarries exploited both in the heart of these features, for example along an exposed thalweg or dry streambed (fig. 5.2c), or along the edge of these features, like an embankment, where the rock is exposed (fig. 5.2d). Millstone quarries are also on flat features such as mountain top plateaux or flatter plains where rock was exposed by a combination of different types of erosion (fig. 5.2e). Finally there is the case of quarries exploiting millstones at outcrops along the coast (fig. 5.2f). The trade of the products from these coastal quarries obviously benefitted from maritime transport.

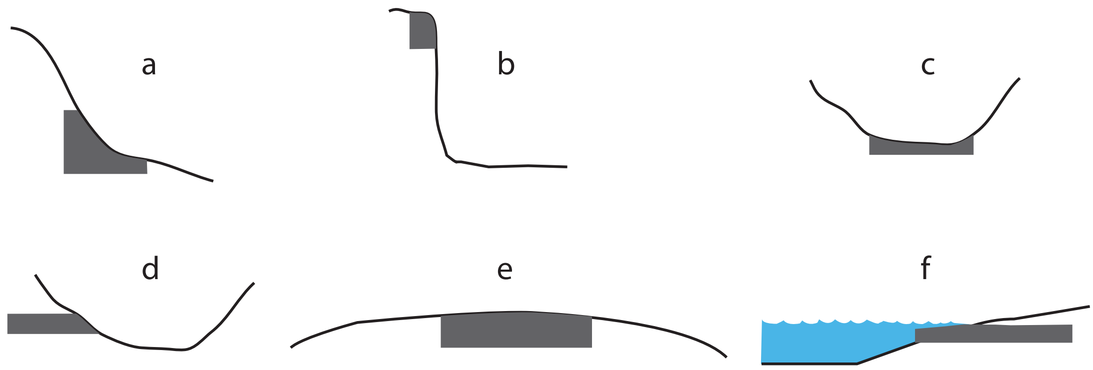


Fig. 5.2: Schematic sections of the topography of bedrock millstone quarries: a) slope quarry; b) cliff or scarp quarry; c) ravine bottom or riverbed quarry; d) valley or ravine edge quarry; e) plateau quarry; f) coastline quarry (drawing by T. Anderson).

Fig. 5.3: Examples of millstone quarries found at that six principal types of topographical formations: a) slope quarry of Loja, La Merced (GR-4b); b) scarp quern quarry of Zagra, Granada (GR-5); c) ravine bottom quern quarry of La Calzadilla, Almaden de la Plata (SE-1a); e) moutain-top plateau quarry of El Tajo, Teba (MA-2); f) the coastal quarry of Chipiona, Cádiz (CA-6).

5.3 "Prospecting" quarries

Millstone production required a rock with specific properties (hardness, porosity, inclusions) suited for grinding cereals. As obvious as this appears, the outcrop had to be visible and readily accessible. No written documents exist detailing how these outcrops were selected and how the outcrop was selected, and in what form it was to be exploited. Millstone makers were obviously not geologists. They did, nonetheless, possess a keen knowledge of rock properties, in part acquired from other millstone makers, and built upon through experience. We can imagine these craftsmen, already in very early times, surveying the landscape, searching for new potential sources. Once identified, to test its quality, a few cylinders were extracted, converting the site in a "prospecting" quarry", a term formulated in recent research in Norway (Grenne *et al*. 2008: 51). Work at a number of these sites continued converting them into a veritable quarries. In other occasions, work was not pursued beyond these initial extractions, such as at La Merced 1 (GR-4a) (GR-5a) and La Cuerda, Siguënza (GU-4). Work at these sites could have been abandoned for a number of reasons unrelated to the problems with the rock. However, on the grounds of classification, we group them, independently under the label of "prospecting" sites. This definition could also be expanded to the single abandoned extraction at Zagra (GR-5b). A scenario is that a mill maker was aware of the presence of many earlier quern extractions and, considering that the rock had been appropriate for querns, made an attempt at scoring a millstone. This attempt was abandoned for no apparent reason (no break or unwanted fissure is visible) permitting us to suppose that the mill maker suddenly became aware of an unidentified problem and decided to move on.

Fig. 5.4: Examples of "prospecting" sites at Loja, La Merced (GR-4a) and Zagra (GR-5b).

5.4. Production techniques (extraction and fashioning)

The first step of millstone production, after identifying a suitable rock, required either extracting rough cylinders directly from the rock mass or detaching blocks by means of levers. The two basic extractive processes required different types of tools and skills and depended, in part, on the properties of the bedrock such as its thickness and the presence of natural fissures. Local extraction traditions also played a role in the choice of techniques.

Quern or millstone fashioning, the phase after extraction, required, at times, another set of tools. As we will see in a later chapter, some millstone quarries were not restricted to one single extraction technique. There are cases where the millstone makers showed versatility and adapting their techniques to the different conditions of the rock.

The following observations related to techniques are based on a combination of sources. First there is the observation of tool marks at the quarries themselves. However, since at most Spanish sites these marks are too weathered and not visible, we have had also to recur to the specialised quarry literature, notably the research J.-C. Bessac in southern France, to define the old stone working tools (e.g. Bessac 1982) and extraction techniques (e.g. Bessac 1996). Our observations are also based on observations gathered from discussions with other specialists during the excavations of several quern or millstone quarries in Switzerland and in France.

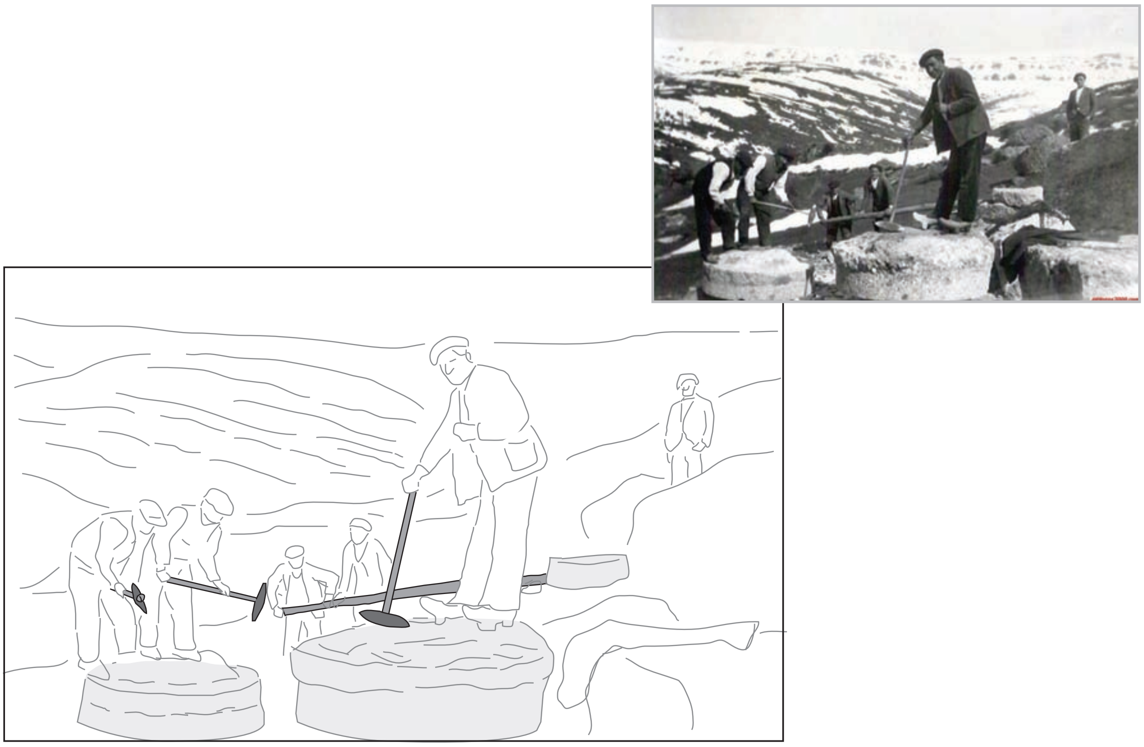


Fig. 5.5: Photograph dating to 1933 of moleros *(millstone makers) at the millstone quarry of Brañosera (Palencia) in northern Spain. Although the scene appears to be staged, it offers a rare glimpse into millstone makers and the tools of their craft, highlighted in the sketch. Three of the workers have picks and in the background the two workers are handling a lever to move or overturn a millstone. The millstones in the centre and the left have been overturned to fashion their second half (photograph from Cuevas Ruiz 2006).*

5.4.1. The tools of the millstone maker

The millstone maker employed a wide variety of tools and *gestes* (actions) borrowed from the tradition of cutting stones for construction. Most of the extracting and fashioning tools fall into two large categories defined by J.-C. Bessac (1996). The first, including the pick, is that of tools associated to the technique of direct or "thrown" percussion (*percussion lancée*). Examples of this type of tool are clearly visible in the 1933 photograph where the *moleros* of Brañosera (Palencia) strike the stone directly with the pick (fig. 5.5). The second tool category, associated with the technique of "indirect percussion" (*percussion posée*), comprises a wide variety of hammers and sledge hammers and chisels and punches, tools that work, by definition, in tandem with other tools. Both techniques can intervene in either of the two phases of millstone production (extraction and fashioning). They are complemented with other tools such as the lever or pry bar.

J. L. González Peralbo cites a notarial protocol in the local archives of Pozoblanco, Córdoba dating to 1619 that lists the possessions of the stone mason Juan de Bargas, a known millstone maker, at the moment of contracting marriage with Francisca Ruiz. Besides a small quantity of money and no house or farm, the record lists his tools: "*barras, almádena, picos, plomada, escuadras, reglas, nivel, cuñas*" (i.e. iron levers, sledge hammer, picks, plumb line, set-squares, rulers, level, wedges) (http://depgeografiaehistoria.blogspot.com.es/2008/02/virgen-de-luna.html).

54.1.1. Direct percussion tools (picks)

The pick is in itself the most important extraction tool of the mill maker. It is composed of a long, wooden handle and an double-pointed iron head. Known since Antiquity, it appears engraved, for example, in a quarry in the Rhineland of Germany (fig. 5.6a) and on a capital of a Medieval Church in province of Zaragoza (fig. 5.6b). The pick is most often used to extract cylinders from bedrock or from large surface boulders. This tool is not exclusively a tool of extraction but is known to have also played a role in the fashioning process. For example, in the photograph of Brañosera (Palencia) the *moleros* are fashioning with picks the rough surface of the second face (the first face, facing down, has already been fashioned).

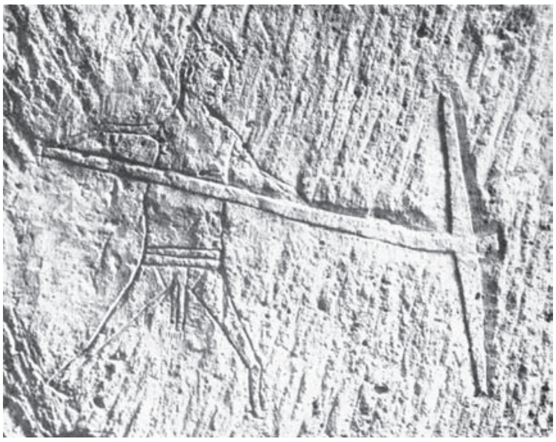



Fig. 5.6: Examples of tools of direct percussion. Left: Engraving from Antiquity of a quarryman with his pick, Kruft, Kr. Mayen (Germany) (photograph from Röder 1957, Plate 21, 1). Right: Scene of a quarryman cutting or shaping a block on a capital of a column of the western entrance to the church of San Miguel de Biota (Zaragoza), 12th century (photograph by Ray Escámez Rivero, flicker, http://www.flickr.com/photos/adfinem/6849827592/).

A smaller version of the pick, the pick axe or mattock, was also known to have been used to carve the holes at the base of the cylinder to lodge wedges and could have been adopted by Spanish *moleros* to rectify the surfaces of millstones during the fashioning phase.

5.4.1.2. Indirect percussion tools (hammer, chisel)

The hammer and chisel in their different forms are the principal tools of "indirect percussion". In the initial extraction phase they were used, at times, to carve the wedge holes at the base of the cylinder. In the fashioning phase these were used to carve the edges and the surfaces of they cylindrical roughout into a perfectly circular shape. These tools also served to pierce the eyes, the spindle hole and ultimately the other different sockets and slots for the handle and rynd fittings. Each millstone maker had his set of tools adapted to his specific needs. For the finer work he also probably used a wooden mallet.

The socketed gad (*pointerolle* in French), is a sort of chisel with a wooden handle that was struck with a hammer that was often associated with mining. It permitted the cutter to adopt postures and attain areas that were not adapted to the use of the pick, such as millstone extractions on vertical planes. This tool, which permits a high cutting precision and leaves a specific set of concentric linear marks, was used to carve out millstones from the walls of the subterranean quarry of La Corbière at Mont Vouan (Belmont unpublished). Although not identified in millstone quarries in our study area, due to the long mining tradition, it cannot be excluded from the panoply of tools of Spanish millstone makers.

5.4.1.3. Leverage tools

Levers and long pry bars also played an important role in millstone production, in particular in quarries where blocks were pried out following natural fractures. In quarries where millstones were hewn directly from bedrock, however, levers were used to remove the cylinder from the hollow. If fashioning took place at the quarry itself, as is often the case, it was necessary to move the roughout from the quarry face a certain distance (about 50 cm) so as to comfortably access all of its sides. In the fashioning stage, levers also served to overturn the roughout to access its opposite face. This is the case of the two men handling a wooden lever measuring about 3 m in length in the background of the photograph of the *moleros* of Brañosera (Palencia) (cf. fig. 5.5). According to Maestro Hernández, the levers in the Palencia mountains, for example, were of a oak, a wood much harder and resistant than beech (2011: 41). Maestro Hernández also quotes oral testimony relating that although were moving or turning roughouts was undertaken by a team of men, a single worker could do the job, on the condition that he be adept with a lever and placing the *leva* (the rock acting as a fulcrum) (Maestro Hernández 2011: 41-42).

5.4.1.4. Other tools

Other tools intervened in millstone production. These included the compass to trace the initial form of the cylinder. Brushes, rakes and hoes were also essential to removing debris from the interior of the circular trench that hindered carrying on work. Shovels of different sizes were needed to load wicker baskets or wheelbarrows to transport working debris from the extraction area to the spoil heap. Troughs were used to retain water to wet down the working areas (to reduce the quantity of dust) or wet wooden wedges to make them swell.

5.4.2. Extraction: cutting cylinders directly from bedrock

The most common technique of cylinder extraction was cutting them directly from bedrock (fig. 5.7). This method resulted in a characteristic feature seen along the quarry face: the circular hollow. This technique is widespread throughout Europe since Antiquity and is identical (except for the shape) to that of quarries where blocks for construction were extracted.

In the context of millstone quarries, the technique of cutting a circular trench is illustrated in detail in the study of a Roman quern quarry excavated at Châbles in the Canton of Fribourg, Switzerland. Here the ancient tool marks were particularly well-conserved permitting the reconstruction of the operation sequence of rotary quern extraction, from the choice by the quern maker of the position of extraction, to the pecking the centre to serve as a reference point to trace the contour of the cylinder with a compass (or simply an iron nail attached to a string), to cutting the trench with the pick, and finally, to splitting the cylinder from the bedrock (Anderson *et al*. 2003, chap. 5).

Modern excavations undertaken recently in the French Jura under the direction of L. Jaccottey (2011), as well as excavations under the direction of A. Belmont at the sites of Claix near Angoulême (Charentes) (Belmont 2011; Belmont *et al.* 2011) and Mont Vouan (Haute-Savoie) (Belmont, unpublished), also reveal a wide range of extraction techniques.

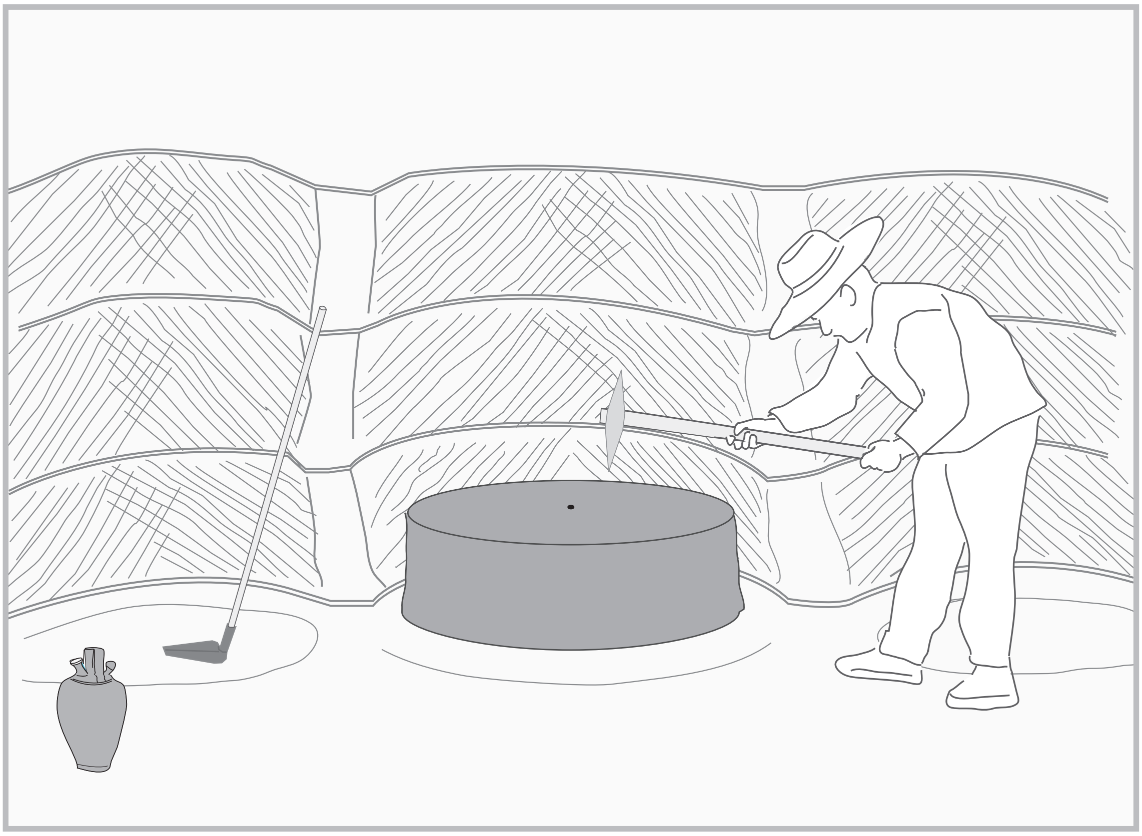


Fig. 5.7: Reconstruction of the technique of extracting a large (Middle Ages to Contemporary) cylinders directly from bedrock by means of cutting a circular trench with a pick. This technique results in tubular quarry faces with diagonal tool marks as seen behind the worker (drawing by T. Anderson).

5.4.2.1. Horizontal extractions

The technique of extracting millstones on horizontal planes requires, initially, the cutting of a circular trench, a task generally executed with a pick. The trench is always cut following an inclined working plane, a technique that facilitates the millstone maker by reducing the resistance of the rock (fig. 5.8).

The trench is cut by multiple, contiguous impacts of the point of the pick called "passes", placed along a predetermined axis. This technique of "passes" (from the French *passes*) results in linear tool marks that, in favourable conditions of observation, appear as multiple, parallel lines both along the border of the cylinder and along the quarry face (fig. 5.9), as illustrated in detail in figure 5.10.

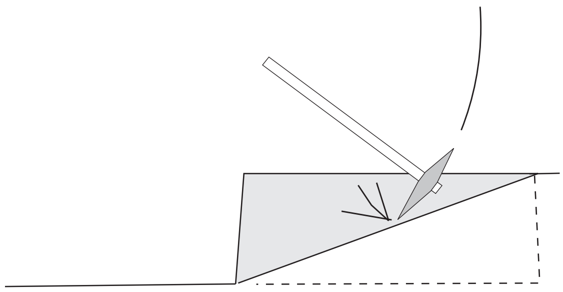


Fig. 5.8: Schema of the diagonal inclination of the passes with the pick. With this inclination, the rock presents less resistance (drawing by T. Anderson).

The trench has to be sufficiently wide so as to allow access to the base of the cylinder both for millstone maker to be able to place one leg (to maintain his equilibrium) and, when the trench is finished, to cut the holes for the wedges to split the cylinder from the rock mass. In the case of small rotary quern extraction (where the quarryman need not place a leg), the width of the trench is modest, from 10 to 15 cm, whereas for cylinders measuring up to 1,50 m in diameter

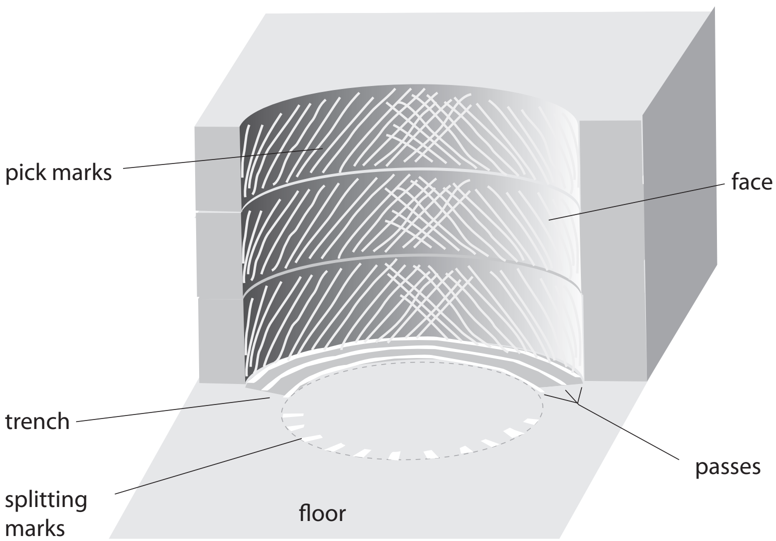


Fig. 5.9: Tubular quarry face resulting from the superimposition of horizontal extractions scored by means of cutting circular trenches with a pick. The quarry floor, in optimal conditions of observation, will reveal at the base of the trench parallel lines corresponding to the passes of the pick and radial splitting marks (wedge holes, chisel marks) (drawing by T. Anderson).

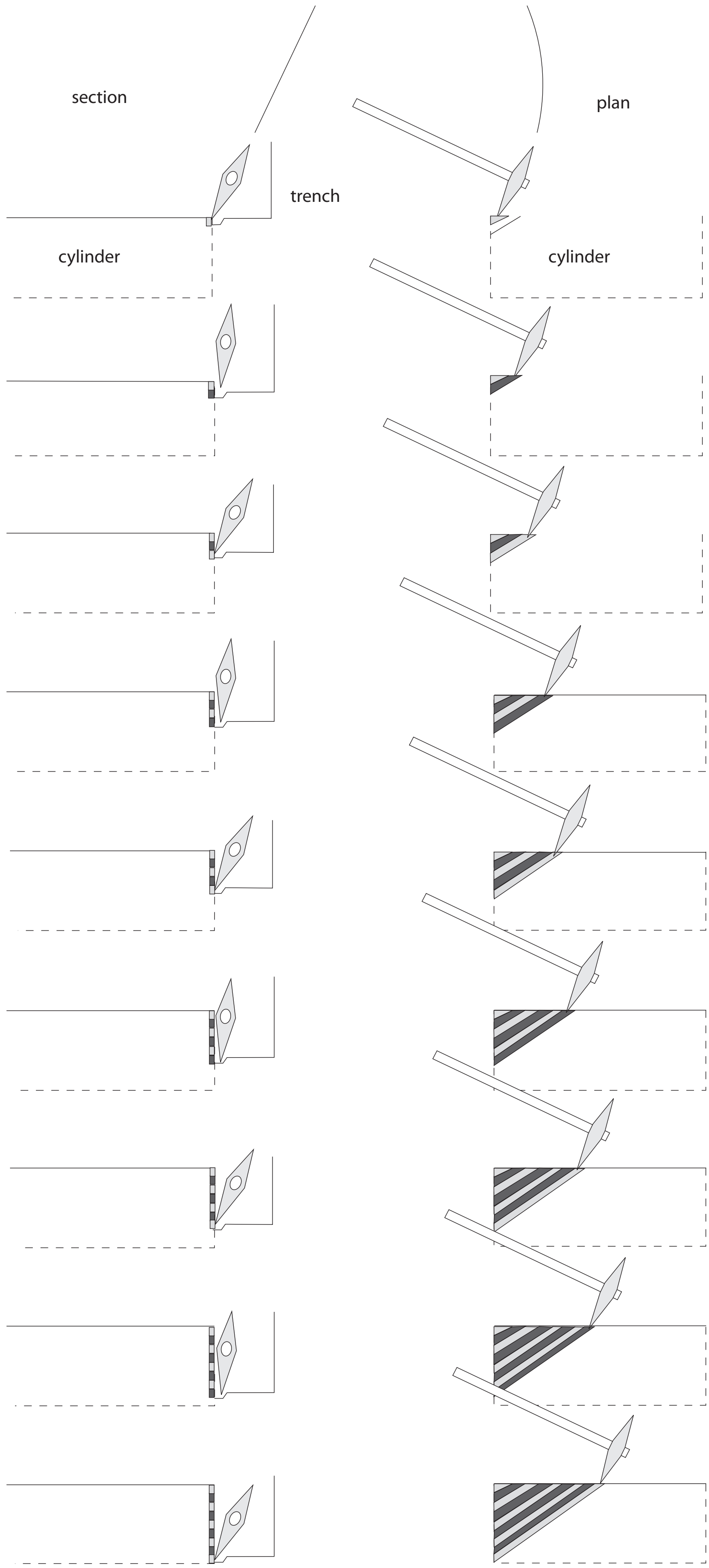


Fig. 5.10: Schematic representation of the cutting of the trench with a pick (direct percussion), a process that produces diagonal lines on both the quarry face and the edge of the millstone. The lighter lines result from direct impact of the pick, whereas the darker colour corresponds to where the rock has broken off (drawing by T. Anderson).

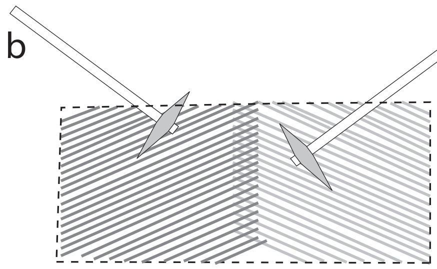


Fig. 5.11: Schema of the diagonal pick marks visible on millstone quarry faces. It is typical to observe two groups of opposite marks in "mirror effect" that result from the mill maker's change of position of the while cutting the circular trench. a) original position of a right-handed quarryman b) secondary position of a right-handed quarryman. The marks of (b) overlap those of (a) (drawing by T. Anderson).

and 60 cm in height, the trench can easily attain the width of between 30 and 40 cm. The number of parallel "passes" depends on the width of the trench. In the case of quern extractions there are usually three. For larger trenches there are more.

In the field, the criteria to determine this technique is the presence of multiple diagonal lines on the quarry faces. It is typical to observe two groups of multiple parallel lines in "mirror effect" (fig. 5.11 - 5.12) that result from mill maker's change of position (his progress is hindered by the quarry wall) while cutting the circular trench. The regularity and symmetry of the tool marks suggest that the quarrymen developed an ambidextrous ability to cut the trench.

Fig. 5.12: Examples of multiple linear diagonal tool marks on tubular quarry faces indication extraction from bedrock with a pick: a) Cabra (CO-1); b) Los Guillares, Padul (GR-7); Moclín (GR-1); Los Guájares (GR-8).

5.4.2.2. Vertical extractions

The technique of extracting millstones following vertical planes, perpendicular to the natural bedding plane of the rock, resulting in vertical circular extraction hollows, has been identified at the following sites: Moclín, Las Pedrizas (GR-1b); Los Guillares (GR-7); Vélez de Benaudalla, GR-10; Peña Harpada (CA-10); El Campillo (HU-1); and Castillo de Locubín (J-1) (fig. 5.13). The number of vertical extractions at most of these sites, compared to the horizontal extractions, is modest and represents only a small proportion of the total. At Los Guillares (GR-7), for example, there are less than a half dozen compared to the hundreds of horizontal extractions.

This site and the modest site of Las Pedrizas (GR-1b) are the only cases where the technique of vertical extractions dominates. At Las Pedrizas the work was vertical because the blocks, after rolling down the slope, ended up in a position where their original bedding plane was vertical. At the larger site of El Campillo Viejo (HU-1), the vertical orientation of the extraction due to the need to follow the natural vertical (or subvertical) bedding planes (fig. 5.14).

In terms of techniques, this type of extraction presupposes different *gestes* by the millstone maker and possibly other tools. Direct percussion with a small pick or indirect percussion with hammer and chisel, permitting the cutter to remain with his back upright, would seem more adapted to this type of work. At Mont Vouan, for example, the tool marks clearly visible at the base of the circular trenches were concentric lines suggesting the use of a socketed gad (Belmont unpublished).

Apart from El Campillo (HU -1), there is no site in Spain where vertical extractions are dominant. In each of the Spanish sites that do show several vertical extractions, the hollows always correspond to single carvings, never multiple "stacks" that result in long horizontal "tubes" that, when combined with a large number of other similar extractions, develop into underground exploitations such as those excavate recently by A. Belmont at Mont Vouan in France. This would appear to indicate that in Iberia the technique was avoided when possible, probably because the position was not comfortable for the *molero*.

Fig. 5.13: Example of vertical circular extraction hollows at the sites of Padul, Los Guillares (GR-7) and Castillo de Locubín (J-1). Extracting in the vertical direction, perpendicular to the naturally bedding plane of the rock, was not common in millstone quarries of southern Spain.

Fig. 5.14: Examples of vertical extractions at the site of El Campillo Viejo (HU-1). This is the only site where the vertical extraction technique dominates (photographs by A. García Veiga).

5.4.3. Splitting cylinders from bedrock

After the mill maker cut the trench around the future millstone, the cylinder had to be split from the bedrock by means of a variety of techniques by either direct or indirect percussion. This was a delicate operation that was not always successful as can be seen at certain sites by semi-circular blocks still attached to the bedrock (fig. 5.15).

The principal splitting technique identified in the south of Spain consisted of fashioning a series of evenly spaced cavities at the base of the cylinder destined to lodge a set of wedges that exerted upward and downward pressure that trigger a horizontal fracture along the base of the cylinder (fig. 5.16a). This type of hole, following a long tradition recorded since Antiquity, endured until very recent times and was adapted to all of the rock types. The best example in our study area is the series of holes spaced along the base of a vertical schist extraction at El Campillo (HUE-1) (fig. 5.17).

This technique has also been identified at the base of horizontal extractions at *Sisapo* (CR-1), Rambla Honda (AL-3) and Plasencia (CC-1) on different types of rocks. The holes at these sites are, however, not sufficiently well-conserved to determine the original shape of the cavity (square, trapezoidal) (fig. 5.18).

Fig. 5.15: Examples of defective splitting from bedrock at Almadén de la Plata (SE-2) and Sisapo *(CR-1). The horizontal fracture at the base of the cylinder was not completed, probably due probably to the presence of a diagonal micro-fissure and part of the cylinder remained in connection with the bedrock.*

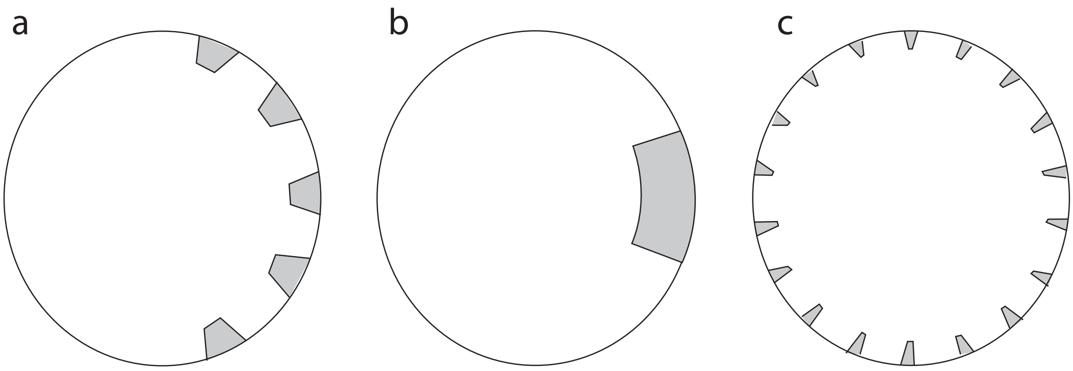
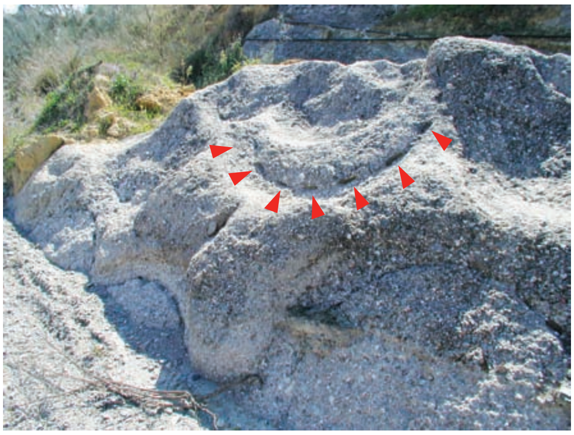


Fig. 5.16: Schema of different types of marks on quarry floors indicating the different techniques of splitting cylinders from bedrock: a) evenly spaced multiple wedge holes; b) large single wedge hole; c) multiple radial pick impacts or chisel marks (drawing by T. Anderson).

Fig. 5.17: Detail of the holes at the site of El Campillo Viejo (HUE-1) carved to lodge wedges to split the cylinder from the rock mass (schist) (photograph by A. García Veiga).



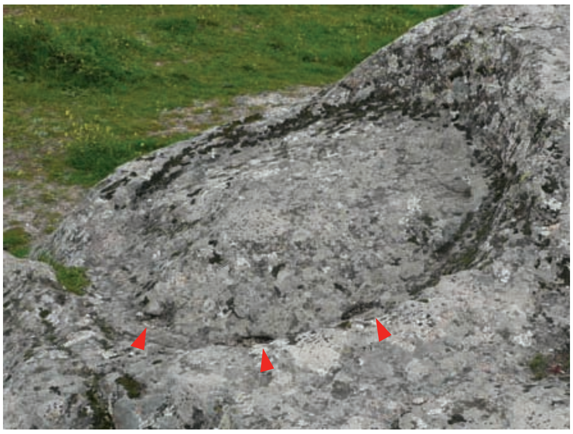


Fig. 5.18: Extraction hollows with tightly spaced multiple small wedge holes at Rambla Honda (AL-3) and larger spaced holes at Placencia (CC-1). The sites exploited, respectively, conglomerate and granite .

A second type, identified only at the Roman volcanic site of *Sisapo*, consists of a large single wedge hole (cf. fig. 5.16b and fig. 5.19), a technique observed at Claix in southwestern France in the context of an Early Medieval limestone quern exploitation (Belmont 2011: 11, fig. 21).

The question that remains unsolved regarding the splitting technique in southern Spain is whether the wedges were of iron, lodged between two metal shims, and struck by a hammer (fig. 5.20), or wooden wedges that fractured the rock when swollen with water (fig. 5.21). There is no evidence to suggest one or the other. The advantage of iron wedges was that the result was more speedy and the wedge could be immediately used again. Wooden wedges, with their slow, gradual pressure, may have been more apt to splitting more delicate rocks that did not resist the sudden pressure imparted from the iron wedge. These questions, however, remain open.

The particular splitting method using the long continuous channel (in French *saignée*) around a third, half or, at times, the totality of the circumference of the cylinder (fig. 5.22), observed in France at Claix (Belmont 2011: 11, fig. 22), and at the Mont Vouan (Belmont, unpublished), has not, for the moment, been identified in Spain.

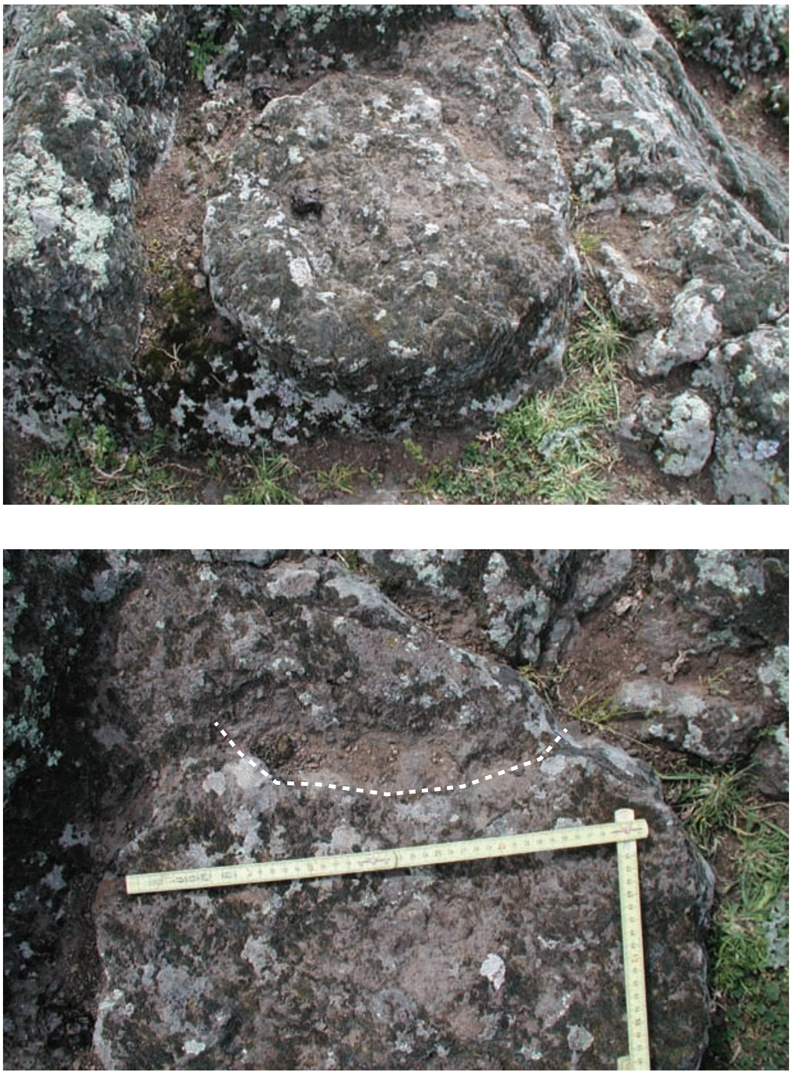


Fig. 5.19: Large single wedge hole along the base of a quern at the volcanic quarry of Sisapo *(CR-1).*

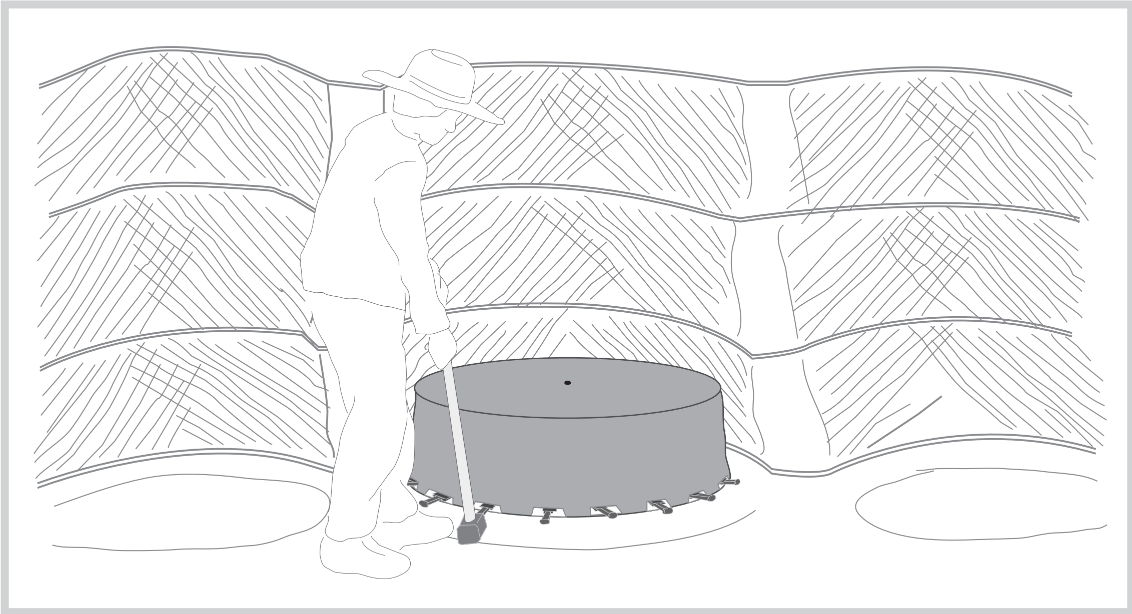


Fig. 5.20: Reconstruction of the technique of splitting a large (Modern to Contemporary) cylinder from bedrock with a series of spaced metal wedges (drawing by T. Anderson).

Fig. 5.21: Reconstruction of the technique of splitting a large (Modern to Contemporary) cylinder from bedrock by means of swelling dry wooden wedges with water (drawing by T. Anderson).

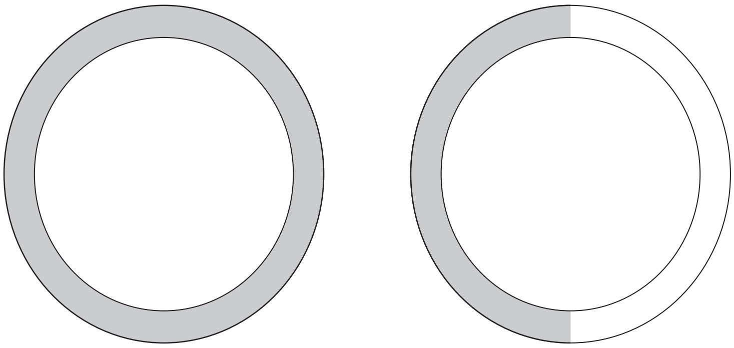


Fig. 5.22: Schema of the long continuous channel technique for wedges along the base of the cylinder covering either part or the whole of the circumference (drawing by T. Anderson).

Neither has the method of splitting by direct percussion employing the same pick used to cut the trench been observed. This technique, avoiding the use of wedges altogether, was pointed out to us by J.-C. Bessac at the Roman quern quarries of Châbles (Canton Fribourg) (and by analogy at the neighbouring site of Chavannes-le-Chêne. Canton Vaud) in Switzerland (Anderson *et al.* 2003) (fig. 5.23). This method results in a number of short, evenly spaced radial pointed marks along the half of the circumference (fig. 5.24)

Another technique, analogous to that of Switzerland, has been observed at the medieval quern exploitations at La Calzadilla, Almadén de la Plata (Seville) (SE-2) and La Atalayuela, Zagra (Granada) (GR-5). It consists of multiple, evenly spaced, radial marks on the quarry floor (cf. fig. 5.16c and fig. 5.25).

Fig. 5.23: Schema of the technique of splitting a quern cylinder directly with a pick, avoiding the use of wedges (from Anderson et al. 2003: 49, fig. 44, drawing by A. Pulido).

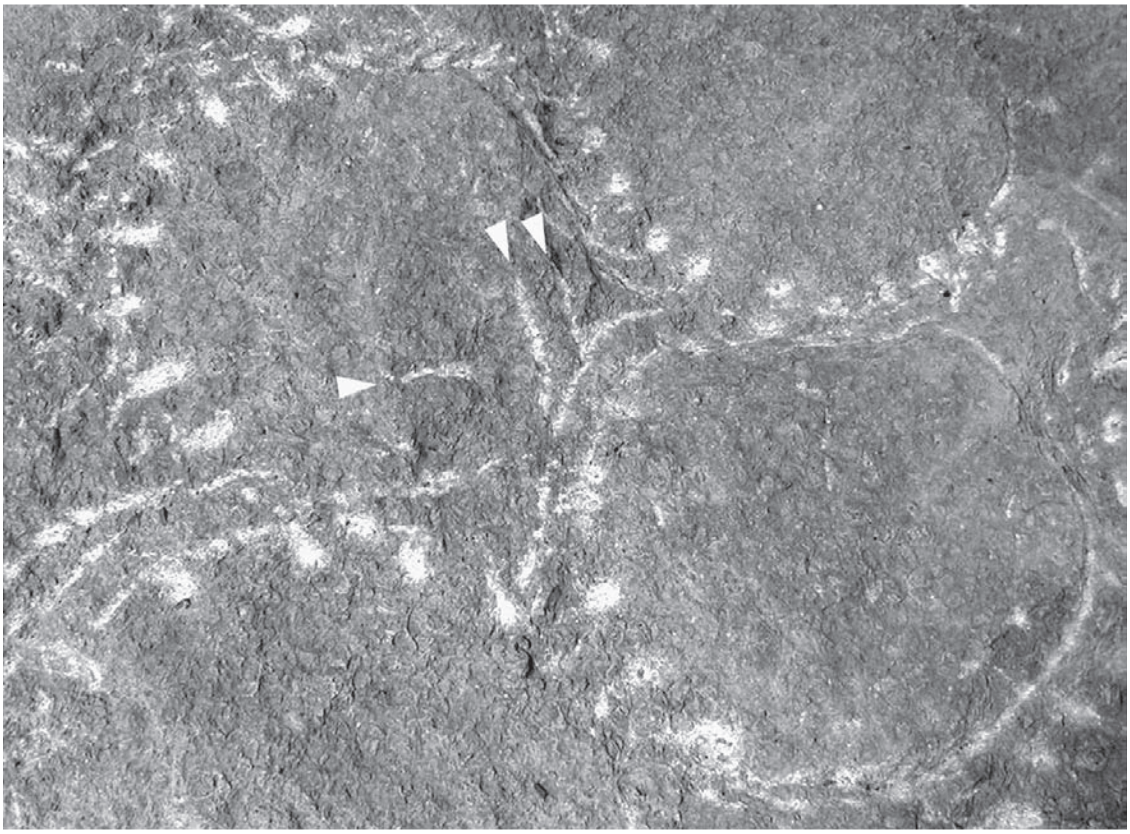


Fig. 5.24: Examples of tool marks on the quarry floor of the quern quarry of Châbles, Fribourg (Switzerland) corresponding to the splitting of cylinders directly with a pick. This technique avoided having to carve wedge holes. The arrows indicate three lines where the pick, before continuing his work, removed bulges from the quarry floor that hindered access to the cylinder's base (from Anderson et al. *2003: 51, fig. 52). We thank Jean-Claude Bessac for pointing out this significant detail.*

At Almadén and Zagra, in spite of being extremely worn, the technique differs from that of Châbles in that the marks are larger and surround the totality of the circumference. They resemble, in fact, the splitting marks interpreted as chisel holes at the Medieval quern quarries as far away as the Balearic Island of Minorca (Sánchez 2006:190, fig. 10) and Norway (Grenne *et al*. 2008: 57, fig. 17).

Fig. 5.25: Quern extraction hollows with multiple splitting marks at Almadén de la Plata (SE-2) and Zagra (GR-5). The small marks, interpreted as chisel work, are tightly spaced and surround the totality of the cylinder.

5.4.4. Extraction: detaching angular blocks from bedrock

The most simple means of block extraction from bedrock, demanding less infrastructure and equipment, is the technique of prying out angular blocks with levers, following the natural angular fractures of the rock. This technique was carried out with long levers first of wood and, in more recent times, of iron (pry bars). To insert the levers the natural fissures had, at times, to be enlarged by iron wedges placed in holes cut by picks, a technique put to use by the modern millstone makers of the Palencia mountains and described by Maestro Hernández (2011: 38). This extractive work took place both following horizontal (fig. 5.26) and vertical layers (fig. 5.27). It served as a means for extracting large blocks for monolithic millstones and smaller blocks for composite millstones.

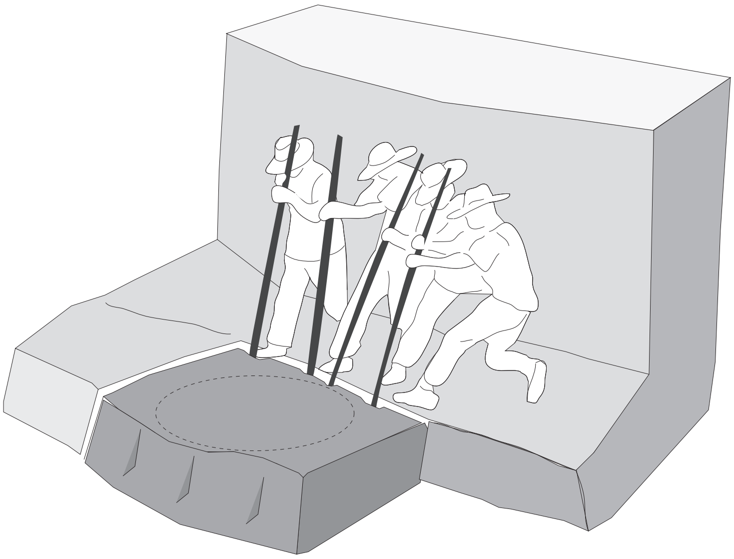


Fig. 5.26: Reconstruction of the technique of detaching an angular block from the quarry floor for millstone production (drawing by T. Anderson based on a photograph from http://burgess-shale.rom.on.ca/en/transcripts/slideshow_1998.html).

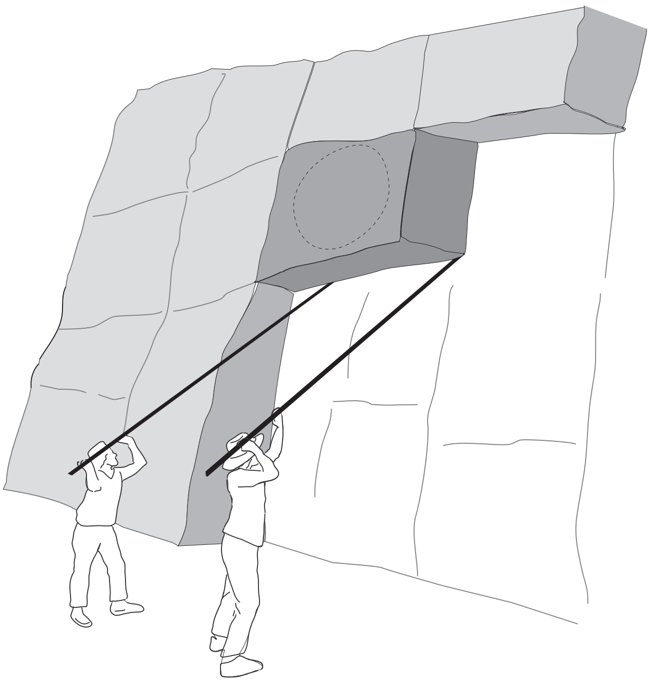


Fig. 5.27: Reconstruction of the technique of detaching angular blocks from the quarry face for millstone production (drawing by T. Anderson).

These quarries are not as simple to identify in the field because the extractions leave little or no characteristic imprint on the quarry face. Depending on the type of rock, this method was not necessarily easy to carry out. It may have required moving a large quantity of overburden to attain the desired rock layer. When the rock did not present obvious natural fractures, the millstone maker was obliged to provoke vertical cleavages by either pounding or wedging to create a space in which to inserted the lever.

Fig. 5.28: a) Strongly inclined columnar jointing at the volcanic quern quarry site of Cerro de Limones (A-1); blocks slightly larger than the size of the querns were probably detached from these "columns" by means of levers or pry bars; b) the quarry face of the Alhama de Granada (GR-6) millstone quarry, where blocks of a specific layer were detached by levers.

Fig. 5.29: Different views of a detached rough angular block abandoned in the process of being fashioned into a millstone at the trench quarry of El Lachar (Jaen) (J-6). In the upper right photograph can be seen the rocks wedged in the vertical facture to detach the future millstone. Since there are no wedge holes visible, we assume the block was detached by a lever or pry bar.

In the context of quern and millstone production, this block extraction technique is recorded in the volcanic quarries of the Eifel in Germany (Harms & Mangartz 2002: 75, 86). It was presumably adopted in southern Spain at the reputed saddle quern quarry of Zujaira (GR-12), the conglomerate trench quarry of Caniles (GR-11), the volcanic columnar jointing at Cerro de Limones (AL-1) (fig. 5.28a) and the limestone cliff of Alhama de Granada (GR-6) (fig. 5.28b).

The best examples of this technique, however, are the trench quarry of Lachar (Jaén) (J-2) and a sector along the cliff of Castillo de Locubín (J-1. In the first case there is an example of a detached block at the floor level in the process of being fashioned into a millstone (fig. 5.29). In the second case there is clear evidence of vertical block detachment as seen through the striking difference between the bright yellow rock colour along an angular face (where blocks were detached), compared to the adjacent greyish, highly weathered, untouched natural faces of the cliff (fig. 5.30).

Fig. 5.30: Views of the face of one sector of the quarry of Castillo de Locubín (J-1). The angular surface and fresh yellow coloration of this sector, where blocks were detached, contrasts with the untouched weathered, grey natural cliff face. A fashioning workshop is located beside this sector (see fig. 5.31).

5.4.5. Quern and millstone fashioning

The fashioning of querns and millstones into a final or near-final shape after extraction was the last major phase of the production sequence before transport and commercialisation. The phase consisted of shaping the different surfaces of the roughout into the desired, perfect symmetrical shape, carve the different types of driving and centring fittings and adjust the grinding surfaces. This took place, for the most part, at the quarry itself. The advantage of working at the quarry was that the object, if defective, could be immediately discarded (fig. 5.31) avoiding the onerous task of their transport.

Fig. 5.31: Examples of querns at the Cerro de Limones (AL-1) and a millstone at Teba (MA-2) that were discarded after they broke during fashioning.

The initial task, applicable to fashioning in all periods, was to set up an amenable work space or "workshop". The advantage of the rotary querns, as opposed to larger models, was that they could simply be picked up by one or two men and carried to the fashioning workshop.
After moving the block to the workshop, the mill maker had to decide if the rough cylinder was apt for an upper or lower stone. Certain blanks bearing rough or slightly broken edges were apt for lower stones but could not serve as upper stones. The proportion of height and diameter of the roughout was also a factor that entered into this choice. For a Roman *sombrero* lower stone, for example, the blank had to be about twice the thickness of that of an upper stone.

Fashioning Prehistoric and Protohistoric saddle querns consisted of knapping the boulder into a rough shape and then preparing the grinding surface by means of the technique of *bouchardage* or pecking. For a detailed description of saddle quern production we refer to the recent work of Luc Jaccottey based on experimentation undertaken in the French Jura (Jaccottey 2011: 294-298).

In the case of rotary querns, different techniques were applied depending on the rock type and whether the roughout was gathered as a surface boulder, a detached angular block or a rough cylinder hewn directly from bedrock.

For rotary querns we rely heavily on examples from the Roman period (there is little to no documentation for the Medieval querns). For the fashioning of more recent millstones, we base our arguments on observations of abandoned products from quarry sites.

5.4.5.1. Fashioning hand-querns

Fashioning rotary querns from small surface boulders (MQ-1a)

The first action, after choosing a suitable boulder, was to give it a rough shape. This could be done by splitting the boulder in two halves. If the fracture was "clean", one of the halves was used as the upper stone and the other as the lower stone (fig. 5.32). At an early stage in the process the surfaces were made uniform by knapping or by pecking. At times, the stone's original surface coincided with the desired shape of the quern and remained unpecked. After giving the stone a general circular shape, its upper and lower surfaces were carved before piercing the eye from each side. The presence of non-pecked surfaces bearing the original patina of the boulder, along with the general hemispherical shape, are elements to identify this type of work.

Although this technique was certainly present in our study area, it has not been identified unequivocally. It has been, however, documented in northern Spain in La Rioja where surface blocks from a riverbed were exploited near a Roman villa (Pascual & García 2011: 287-289).

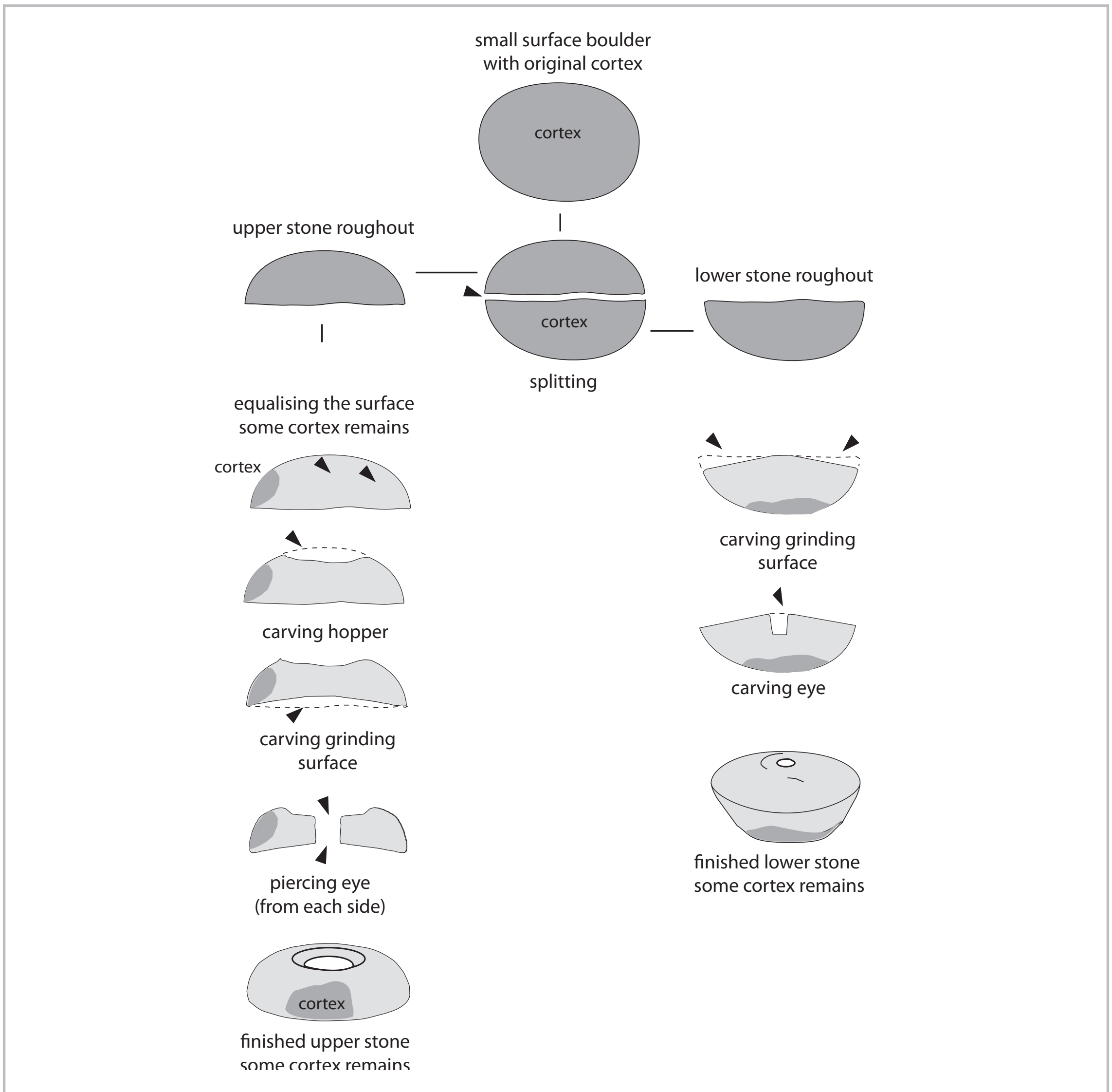


Fig. 5.32: Schema of the fashioning of rotary querns from rolled surface boulders. Patches of its original cortex bearing a different patina betray its origin as a surface boulder (drawing by T. Anderson).

Fashioning rotary querns from angular blocks (MQ-2b)

The process of fashioning angular blocks into rotary querns is often associated with exploitations of very hard rocks. The detailed "*chaîne opératoire*" of this type of type of fashioning has been defined recently by members of the Groupe Meule, base on the observation of querns at the site of Portus (Collonge-en-Charollais, Saône-et-Loire) in France The detailed schema (fig. 5.33). is certainly applicable to workings in the south of the Iberian Peninsula.

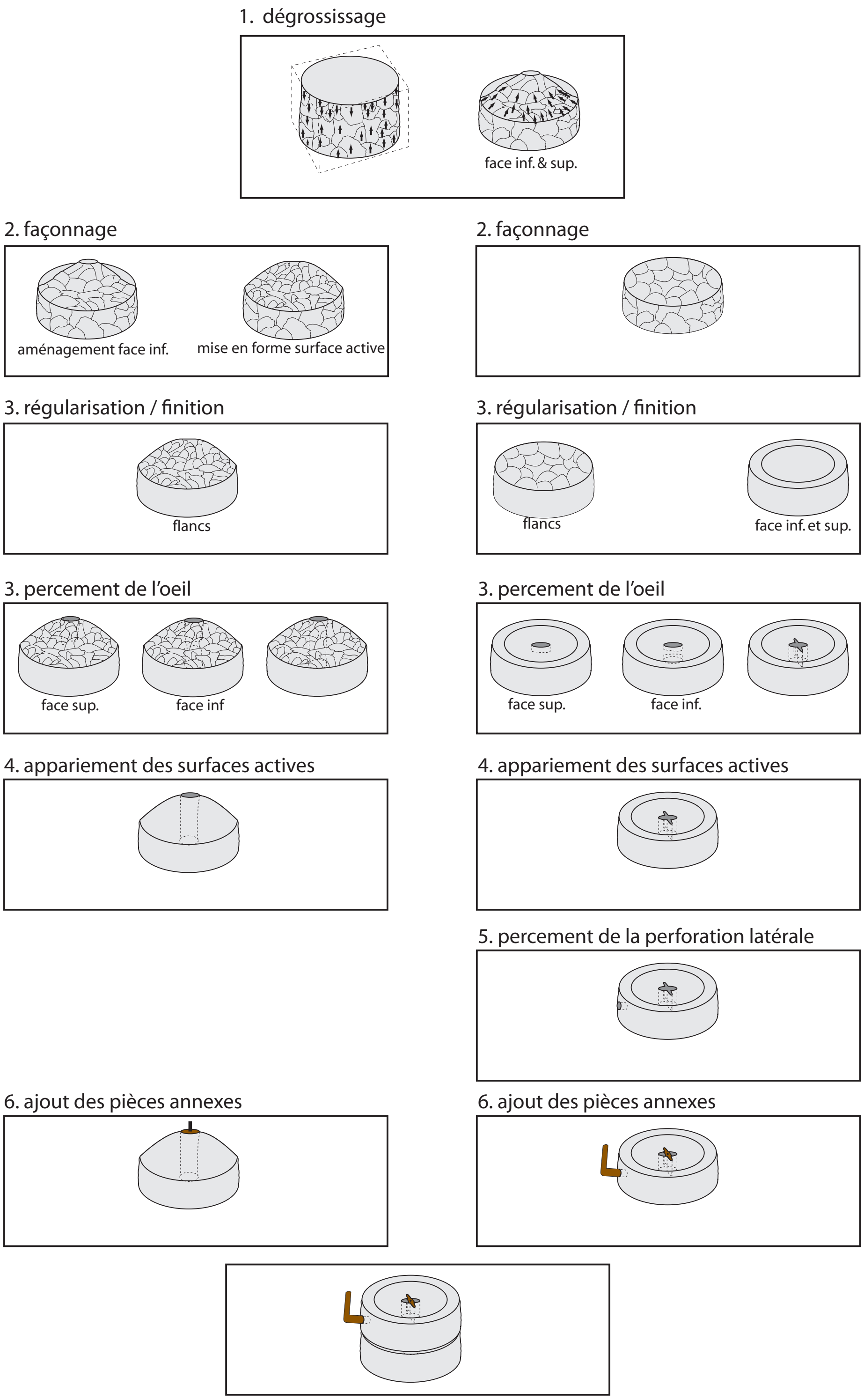


*Fig. 5.33: Example of a "*chaîne opératoire*" of quern fashioning from angular blocks based on observations at the quarry site of Portus (Collonge-en-Charollais, Saône-et-Loire (from Jaccottey* et al. *2011: 194, fig. 39).*

A detailed study similar to that of Portus is still waiting to be undertaken in southern Spain. We present, nonetheless, in a schematic manner, a sequence similar to that of Portus based on ourobservations at the Roman volcanic productions at Cerro de Limones (AL-1).

The process began after first prying out angular blocks from the bedrock (volcanic columnar jointing). These were then knapped into a rough cylindre by means of direct percussion (with a hammer?), a phase that left rough scars on the different surfaces (fig. 5.34). Upper stones were scored from the thinner cylindrical blanks, whereas, lower stones, due to the central protuberance (the future central collar around the eye of the "*sombrero*" model), required thicker roughouts (fig. 5.35).

The finer fashioning work was carried out with hammer and chisel (fig. 5.36). From what we have observed, the eyes were cut systematically at the quarry site. This "dangerous" step, undertaken from each side, explains part of the high number of unfinished querns.

The finer cutting of the rynd did not systematically take place at the quarry. Of the hundreds of discarded querns, only one shows evidence of the cutting of the radial slot that served to lodge the crosspiece that served both as the base of the handle and as a rynd (fig. 5.37).

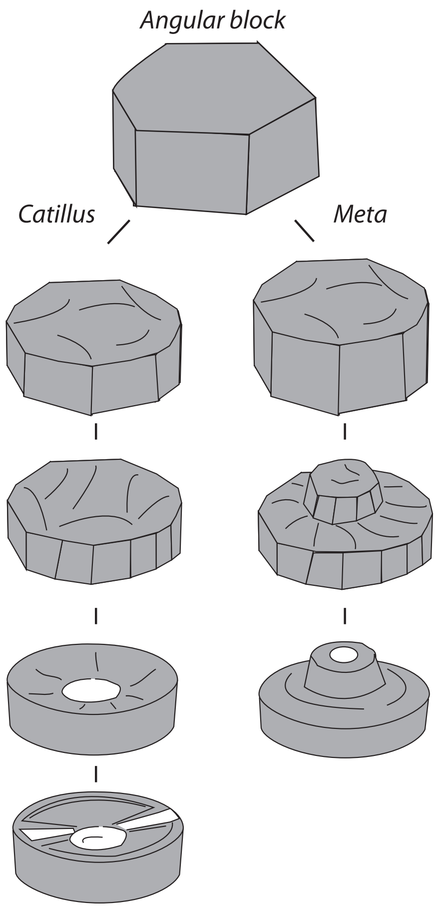


Fig. 5.34: Schema of the main phases of fashioning rotary querns from angular block quarry of Cerro de Limones quarry (AL-1) where radial slot catilli *(left) and the "*sombrero*"* metae *(right) were hewn from multiple faceted blocks detached from volcanic columns (drawing by T. Anderson).*

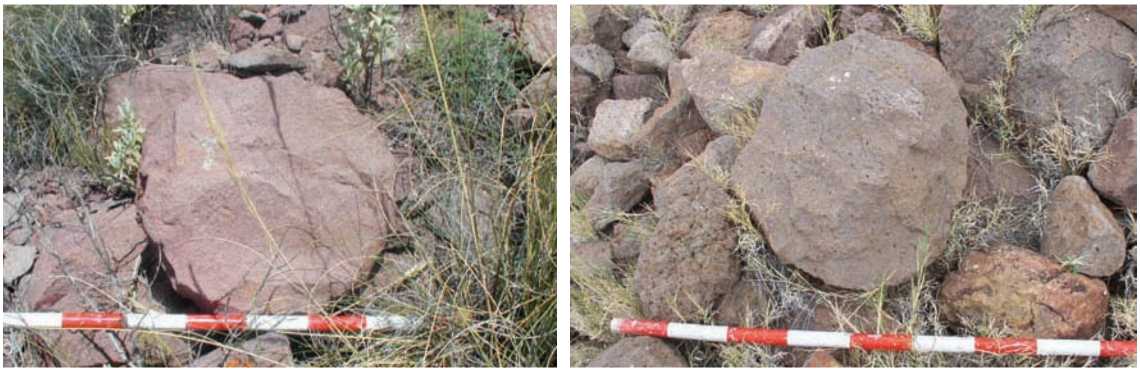


Fig. 5.35: View of volcanic rock flat cylinders from Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2) roughly knapped into shape leaving knapping scars before being fashioned into upper stones.

Fig. 5.36: Examples of roughly knapped lower stone (sombrero type) quern roughouts at the sites of Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2).

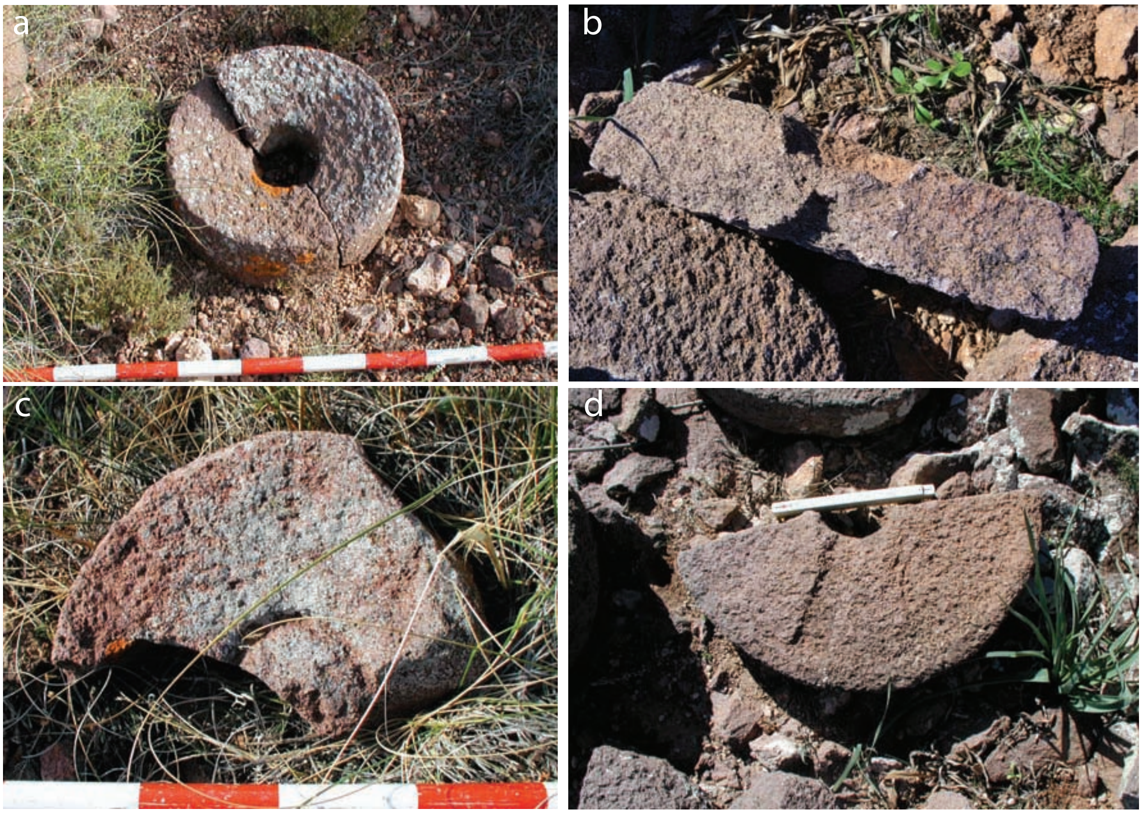


Fig. 5.37: Examples of querns abandoned at the quarry of Cerro de Limones (AL-1): a) The catillus *broke in the final stages of fashioning; b) the* catillus *eye was carved from both sides; c) the fine circular line indicates the eye was carved with a chisel; d) the outer rim and crosspiece slot was being carved when this* catillus *broke.*

Fashioning rotary querns from extractive (true of block) quarries (MQ-2a)

The different steps of fashioning querns from extractive quarries also cannot be established from evidence in southern Spain. The few sites of this type, for example, Trafalgar (CA-1) and Rota (CA-3) for the Roman period, and Almadén de la Plata (SE-1) and Zagra (GR-5) for the Middle Ages, are all true extractive sites devoid of abandoned roughouts. To describe this technique we turn to the *grès coquillier* quarry of Châbles, Switzerland where the sequence has been reconstructed based on the observation of abandoned querns with well-conserved tool marks, as well as through experimentation undertaken with professional stone masons (Anderson *et al.* 2003: 47; 54-56).

The principal element to retain related to the fashioning of softer rocks with more grainy textures (sandstones, conglomerates, limestones) was that they did not require a first phase of rough knapping and therefore do not bear the typical knapping scars (similar to those on flint). They were worked directly from the rough cylinder by indirect percussion with hammers (iron head, wooden mallet) and chisels (punches, pointed and bladed chisel). The marks of these tools were either rounded peck marks corresponding to single chisel strokes or linear marks corresponding to a series of contiguous strokes (fig. 5.38).

An important detail in this step is that the working direction of the chisel (fig. 5.39), to avoid any unwanted break that would abruptly end what had been an investment of many working hours, had to always point to the heart of the rock. This required fashioning one half of the stone at a time (i.e. one surface and one half of the edge) which leaves a sort of "paunch" (from the French "*bourrelet*") along the circumference. This detail is visible at Châbles at different production sites in different periods throughout Europe, (cf. fig. 5.5).

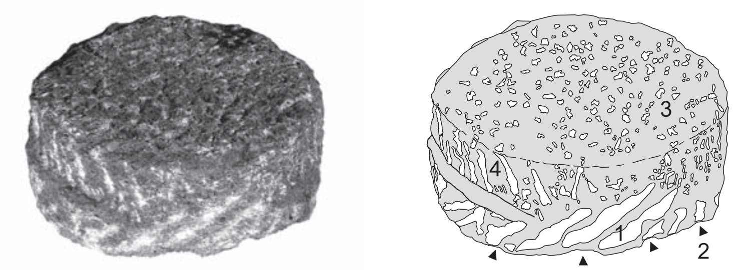


Fig. 5.38: Cylindrical roughout from the true extractive quarry of Châbles, Fribourg, Switzerland. The pecks (no. 3) on the upper surface are from single pointed chisel strikes, whereas the thin vertical lines on the edge (no. 4) are multiple contiguous chisel strikes. The "paunch" (bourrelet) indicating work on one half at a time is visible to the bottom left of each representation. The larger diagonal lines, no. 1, are the original extraction pick marks and no. 2 are the splitting cavities (from Anderson et al. *2003: 55, fig. 61, drawing by T. Anderson).*

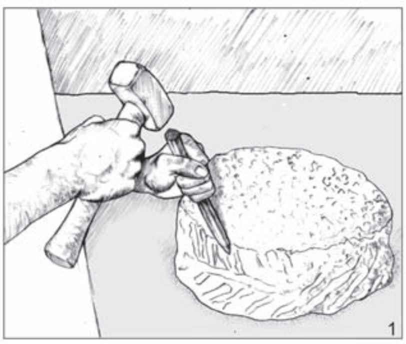


*Fig. 5.39: Example of fashioning a sandstone (*grès coquillier*) rotary quern with hammer and chisel at the site of Châbles, Fribourg, Switzerland. One half was fashioned before turning the cylinder around to fashion the second half, resulting in a "paunch" along the base (from Anderson* et al. *2003: 54, fig. 60, drawing by A. Pulido).*

5.4.5.2. Fashioning Modern and Contemporary monolithic millstones

Large monolithic millstones in Modern and Contemporary times were fashioned from extractive quarries, of both the true and block types. The process consisted of eliminating the unnecessary rock, bulges, rectifying the surfaces and edges and piercing the eye. Since millstones of Modern and Contemporary times were mostly cylindrical, blanks served both for upper and lower stones. This differed from that of earlier work where a preliminary sorting was done, separating those that were better adapted for an upper stones from those that were suited for lower stones. Fashioning work in more recent times also differed from early quern work in that the first step was to prepare a work space around the stone. This required moving the stone, at least slightly, because its original position, after splitting from bedrock, was too near the quarry face to be fashioned comfortably.

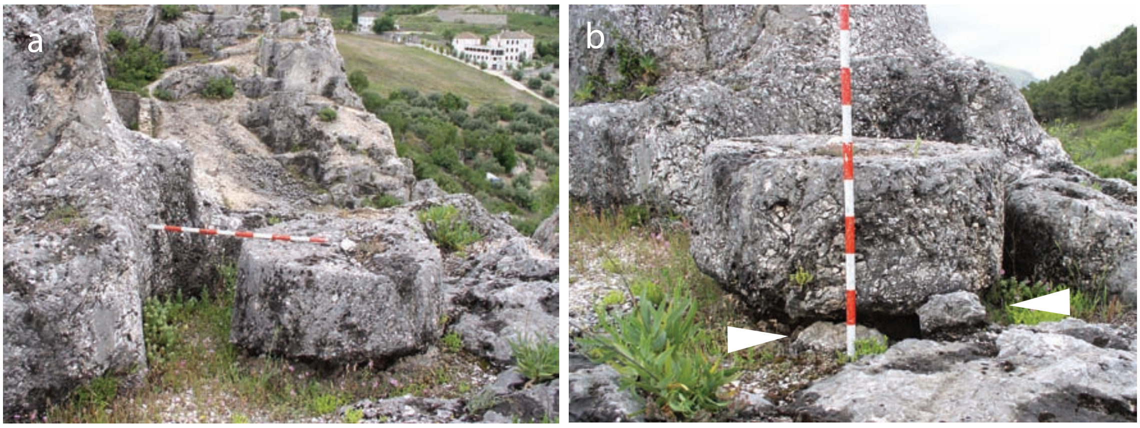


Fig. 5.40: Views of an abandoned millstone from the site of Moclin (GR-1). After splitting it was a) displaced from the quarry face a distance of c. 50 cm (to the left in the picture) to be able to access its back side; b) it was also propped up on rocks to facilitate further handling with a lever.

Fig. 5.41: View of a millstone at Teba (MA-2) propped up by a rock for fashioning.

Fig. 5.42: Rocks at Lora de Estepa (SE-4) surrounded by fine working debris that probably propped up a millstone while it was fashioned.

While moving the millstone with long (probably wooden) levers like those seen in the photograph of the Brañosera *moleros* (cf. fig. 5.5), the workers took advantage to slip one or several large rocks under the stone to create a gap where the lever could be inserted during further handling (Maetro Hernández 2001: 42). This propping up is seen, for example, at Moclin (GR-1) (fig. 5.40) and Teba (MA-2) (fig. 5.41). At Estepa (SE-4), groups of rocks arranged in a circular fashion in an area of about one metre in diameter (corresponding to the size of a missing millstone) and surrounded by a cloud of fine working debris, can be interpreted as fashioning workshops (fig. 5.42).

Carving first took place on one half of the stone, that is, the circular surface and half of the edge, before the stone was reversed to carve its other side.

The photograph of the millstone makers from Brañosera shows that the fashioning of the millstone was undertaken with the pick, the same tool used for their initial extraction. This pick work was certainly completed by fine hammer and chisel work in the later stages of fashioning, that is, the fine work of the grinding surface and the piercing of the eye.

This technique of carving in the direction of the "heart" of the stone, observed since at least Roman times (Anderson *et al.* 2003: 55-56), was intended to reduce the possibility of an unwanted fracture. This technique is illustrated in the photograph of the *moleros* of Brañosera. The workers are fashioning the surface and upper edge after having fashioned the opposite face and half of the

Fig. 5.43: Frontal and lateral views of millstones abandoned after fashioning one half: a) Castillo de Locubín (J-1) and b) Peña Harpada (CA-10) The Castillo de Locubín example is still in its original working position.

edge (*cf.* fig. 5.5). This fashioning technique is common to see on abandoned millstones at different sites. The half-fashioned example at the quarry of Castillo de Locubín (J-1) is still propped up in its working position (fig. 5.43).

Most of the finer elimination of unwanted rock was carried by hammer and a variety of pointed and bladed chisels (fig. 5.44). When the work was more delicate, the millstone maker could use a wooden mallet. To assure a perfectly circular shape, he resorted to a compass or simply an iron nail tied to a string. To assure that the flat surface was perpendicular to the edge, he used a set square.

Another aspect that appears to be common to the more recent millstone quarries in the south of Spain, at least to those where abandoned roughouts are numerous (Moclín GR-1, Vélez de Benaudalla GR-10, El Torcal MA-1, Teba MA-2, Los Frailes CO-1, Cerro de Limones AL-1, Castillo de Locubín J-1, etc.), is that the eye was pierced at the quarry site itself (fig. 5.45). This is probably done for two reasons: to "sound" or test the centre of the stone for possible defects and to facilitate future transport.

Fig. 5.44: Reconstruction of the technique of fashioning a large Modern or Contemporary millstone (drawing by T. Anderson).

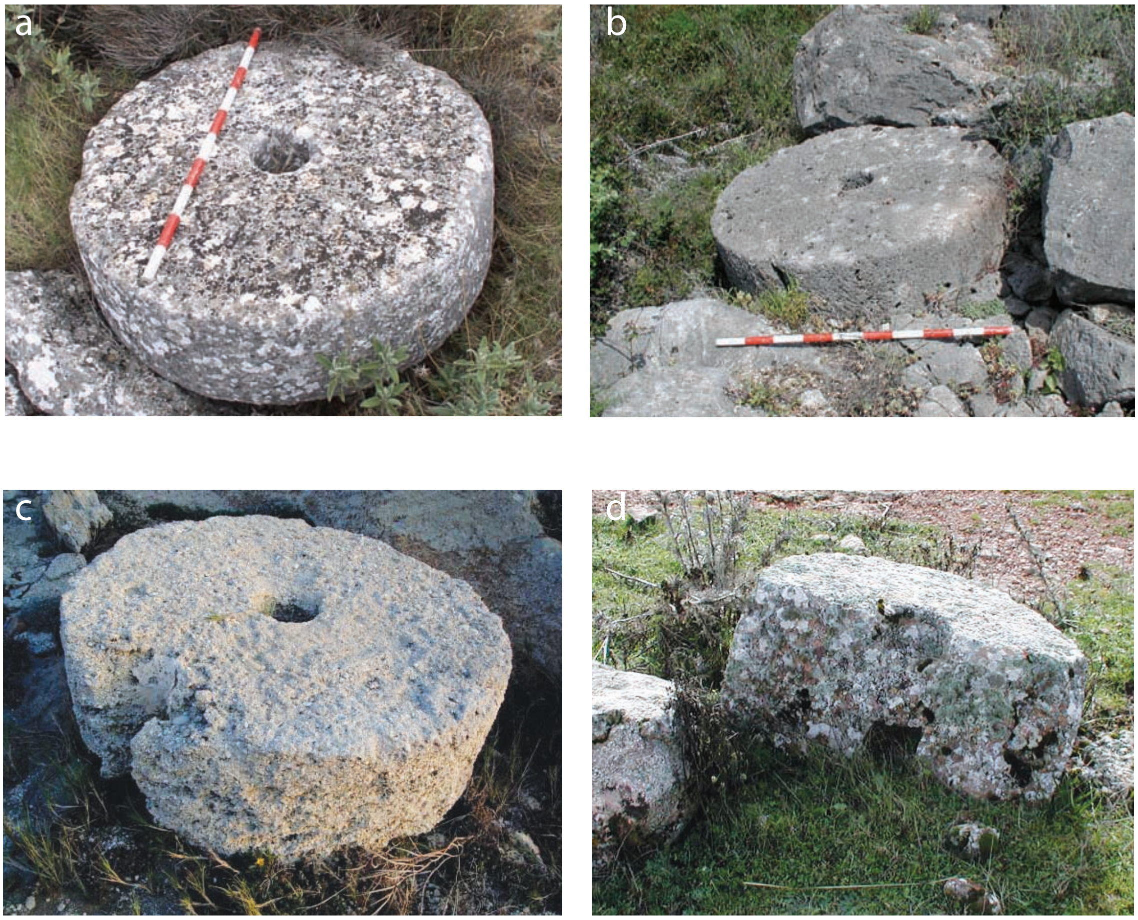


Fig. 5.45: Examples of abandoned millstones with pierced eyes: a) Teba (MA-2); b) Vélez de Benaudalla (GR-10); c) Guardias Viejas (AL-4); and d) El Torcal (MA-1). The millstone at El Torcal probably broke during the piercing of the eye.

5.4.5.3. Fashioning composite millstones

The majority of the millstones we have examined are monolithic, that is, fashioned from single blocks. Composite millstones, made up of segments cemented together with plaster (or cement) and bound by iron bands along their girth, are hardly known in our study area and their quarries are difficult to identify. Some could have been assembled from fractured monoliths.

An early reference to a composite millstone, dating to 1114 (during the Islamic domination), is in a contract related to the lease of a watermill. The contract states that the new stone must measure a diameter of four *empans* (about 1,06 m) and be composed of 8 fragments (Lagardère 1991: 109).

Other references to composite millstones in our study area date to 1491 and 1492, related to the transport of "two-piece stones" to mills in the city of Córdoba (Córdoba de la Llave 2003: 305). The Codex of Juanele Turriano from the 16th century records that this type of millstone was destined to mills either found in difficult terrain, that could not be attained by carts, or to mills in areas where there was no quarry that produced monolithic stones (Vol. III, transcription of 1996: 351).

Turriano proposes two means of assembling composite millstones (fig. 5.46). The first, using five stones, assembled the blocks (B-E) at right angles around a central square (A). The second, made up of four stones, assembled the blocks around a central triangle (Juanelo Turriano - Vol. III: 351, fig. 204). It is the first, according to the author, that is more rigid.

Composite millstones in the mountains of the Alpujarra (Almería) are called "*cuarterones*" (Rodríguez Monteoliva 1989: 705), and contrary to what their name (quarters) implies, they were composed of between five to seven blocks.

In our study area, the only site reported to have produced composite millstones, according to an old historical source, is Albaida (CO- 7) (Cordoba de la Llave 2003: 306 footnote 26). Composite models were also presumably made at Alhama de Granada (GR-6) (fig. 5.47), and more recently, in the dire times after the Spanish Civil War, in Cádiz at the Aguadulce (CA-4) and Roa Martín (CA-5) (J. A. Martínez, pers. comm.). There are certainly other exploitations that made these stones. These site, however, are probably impossible to distinguish from those producing building blocks, especially if millstones were not assembled, and at times abandoned, *in situ*. An advantage of this type of production, certified in France, was that the tool fee for blocks at road tolls was much more reasonable than that of finished millstones (A. Belmont pers. comm.).

The majority of composite millstones seen today in southern Spain are *muelas francesas,* imported since the middle of the 19th century (fig. 5.48), and vestiges of the last generation of traditional watermills, before the introduction of the industrial methods of cereal grinding that are in use today.

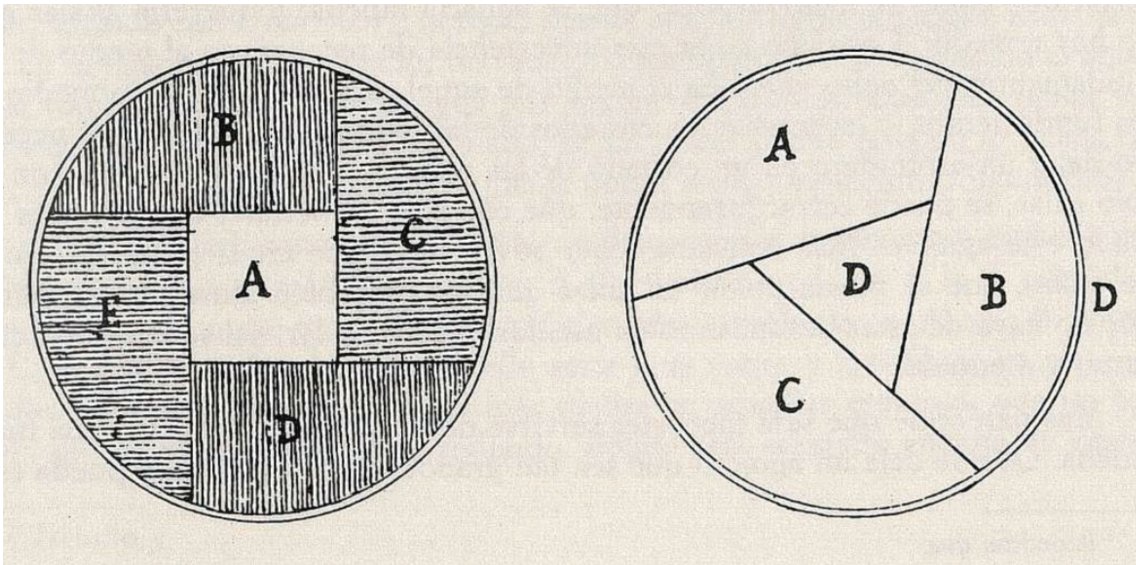


Fig. 5.46: Schema of the two types of composite millstones proposed in the pseudo Juanele Turriano Codex. The schema to the left with five stones is more solid, according to the author, than the model to the right (from pseudo Juanelo Turriano 1996, Vol. III: 351, fig. 204 1996. *http://issuu.com/juaneloturriano/docs/21librosingeniosymaquinastomo_iii* .

Fig. 5.47: Example of a semicircular block from the site of Fuente de los Morales, Alhama de Granada (GR-6). This block was possibly a segment of a composite millstone.

Fig. 5.48: Example of a composite French Burr millstone. This millstone decorates a park in the small town of Moclín, Granada. Ironically this stone was in use in a flour mill in the town that has the most celebrated millstone quarry in the Province of Granada (GR-1).

5.5. Quantifying the duration of making a millstone

The time invested in the fabrication of a millstone, from its extraction to its fashioning, depended on the size of the product, the hardness of the rock and the skill of the mill maker. From our single experiment in Switzerland for a rotary quern, the total time of manufacture by a professional stone mason, including extraction and fashioning, was between two and three days (Anderson *et al.* 2003: 47, 59). This experiment was undertaken on a shell-rich sandstone that was relatively easy to carve. If we were to have repeated the experiment several times we suppose we could have whittled the total work time by about half.

Extraction of rough blocks for rotary querns at the Cerro de Limones (AL-1) or Hoya del Paraíso (AL-2), work done with a lever, was probably undertaken quickly, in a question of less than an hour. Knapping the block into a rough shape, was also relatively quickly done, probably in less than a day. The fine carving of the perfectly circular shape and the cuttings of the eyes, receptacles, handle and rynd fittings and adjustments of the grinding surfaces, probably took a few days. At other quern quarry sites with hard rocks where cylinders were hewn directly from the bedrock, such as *Sisapo* (CR-1), the time of extraction would obviously increase. This larger investment in time of the extraction phase, would nonetheless, reduce the time of the subsequent fashioning.

Maestro Hernández explains that in the Mountains of Palencia the process of manufacture of a single millstone (not a couple) measuring over a metre in diameter by a small team of specialists took between four and seven days (Maestro Hernández: 2011: 43). This provides an idea of the investment of the time of manufacture, roughly double that of the smaller handquerns, for millstones destined to watermills.

Of the old written sources we only have one reference indicative of the quantification of millstone production. El Berrueco (CA-8), according to Madoz, at five different extraction sectors manned by 23 men, produced 64 millstones for water and windmills and 480 millstones for *tahonas* on a yearly basis (Madoz 1846, Vol. 4: 290). Here, as in the case of Palencia, we interpret these as single stones, not a pair, since it was common in the 19th century, due to millstone wear, to replace one stone at a time. This suggests a total of 544 millstones a year, or about 1,5 millstones a day (based on working every day of the year). If we suppose that the teams were composed of four to five men, this would mean that each team, working continuously every day of the year, could produce slightly more than 100 millstones, which estimated on a weekly basis would come to about one a week by team, a number similar to that of the Palencia *moleros*. Since they certainly did not work every day of the year, and since the rock was probably softer and easier to carve than the conglomerate of Palencia, weekly production was certainly higher, probably about two by a team.

All said, depending on the intensity of work, the volume of production at a millstone quarry could attain a high number in a question of a short time.

6. MILLSTONE QUARRY CLASSIFICATION

From observations in the field of about forty millstone quarries (MQ) in the south of Spain, as well as consulting quarry literature made elsewhere in Europe (Bessac 2003; Walton 2004; Martínez Torres 2008), we propose that millstone quarries can be classified into two major categories, contingent on whether the rock exploited was loose, surface material (MQ-1), or, what was more common, bedrock (MQ-2) (fig. 6.1). These major categories can, in turn, be subdivided. MQ1a and MQ1b are defined depending on the sized of the surface block, whereas MQ2a and MQ2b, are contingent on whether the extraction was carved with a pick directly into the bedrock yielding circular hollows, or if the extraction was an angular block detached with levers.

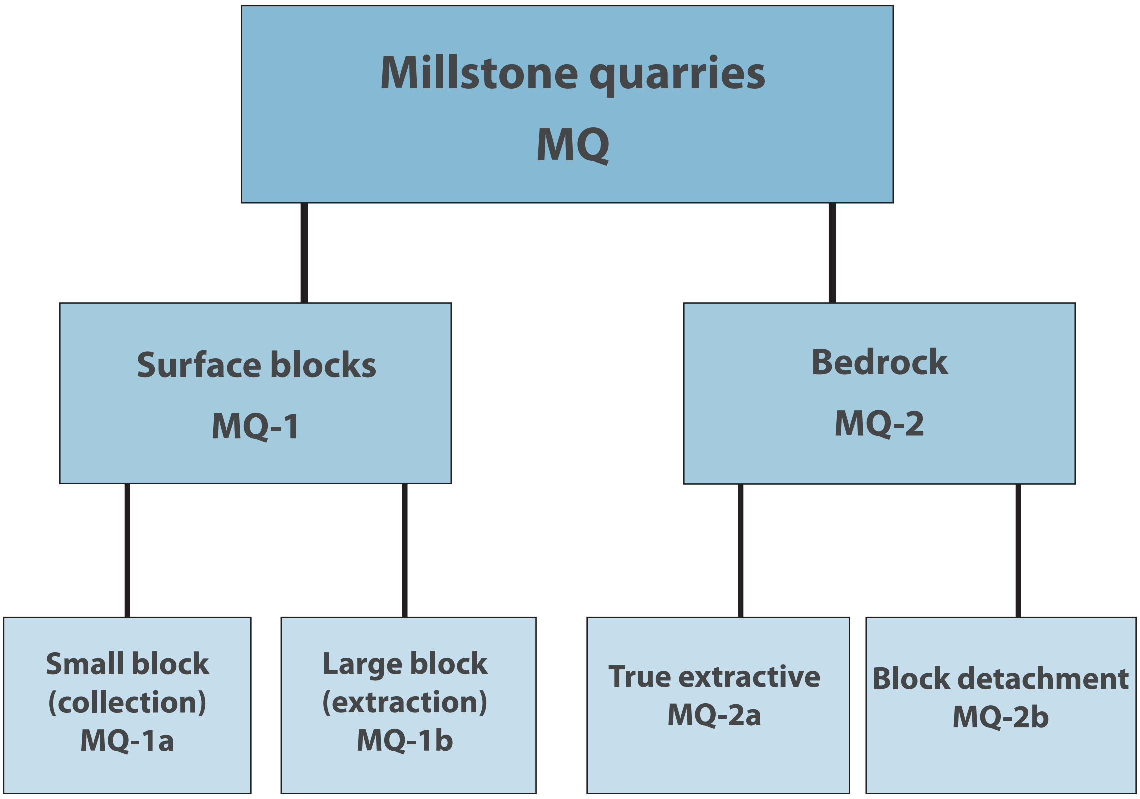


Fig. 6.1: Organisational chart of the classification of millstone quarries identified in southern Spain.

6.1. Surface block millstone quarries (MQ-1)

6.1.1. Small surface block collection (MQ-1a)

A single small boulder or slab collected on the surface, to be hewn into a quern or millstone does not constitute a quarry. However, the repeated exploitation for millstones of certain geographical features with concentrations of transported rocks such as moraines, riverbeds, ravines, screes and taluses can be considered quarries (fig. 6.2). Due to the natural shape of the small boulders, elongated in the case of saddle querns and rounded for rotary querns, the process of fashioning was reduced to a minimum. This type of site obviously did not require the cutting tools and skills of a more complex bedrock extractive quarry. As we will see at the end of this chapter, a criterion to identify querns made from small surface blocks are typically hemispherical, whereas those from extractive quarries are cylindrical.

Since these quarries leave little or no material evidence, none has been positively identified in our study area. They must have been common, especially thoughout Prehistory and Protohistory. They explain the numerous garnet mica schists and conglomerate saddle querns (Delgado Raack 2008: 138) in the settlements of the Millares and Argar cultures throughout southeastern Iberia. We would expect the same model of exploitation in the granite fields of southwestern Spain where rounded boulders sculpted by nature abound. Furthermore, surface collection from screes and taluses in the volcanic district of Cabo de Gata could account for some of the pre-Roman querns of volcanic material.

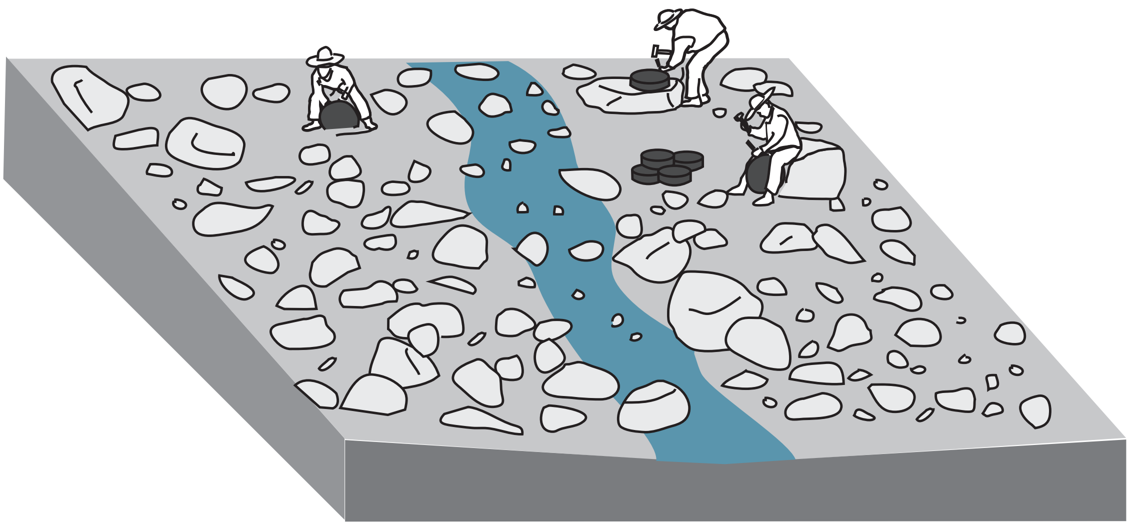


Fig. 6.2: Schematic reconstruction of a MQ-1a type of millstone quarry collecting and fashioning small surface boulders (no extractive phase) (drawing by T. Anderson).

This type of quarry was also known in Roman times. In the Province of La Rioja in northern Spain, for example, there is evidence that small rolled boulders were collected in nearby alluvial deposits and hewn in rotary querns. The proof of this is that on certain surfaces of the boulders one can observe their original rounded cortex (Pascual & García 2010: 287-288). These locally manufactured querns were an alternative to those produced on a larger scale in bedrock quarries.

In our study area, a part of the production of the Roman volcanic quern quarries of Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2) also probably profited from this type of surface material (fig. 6.3).

Fig. 6.3: Examples of the scree and talus at the Cerro de Limones quarry (AL-1). Part of the quern production could have been fashioned from this loose surface material.

6.1.2. Extracting from large surface blocks (MQ-1b)

This second quarry type differed from the first in that it exploited surface blocks of a scale much larger than those of MQ-1a, large enough to permit the scoring of one or several millstones and required both the use of extraction tools (picks) and the mastery of the skills to cut through rock. This quarry type is divided into several subtypes. In the case of MQ 1b-1-3, the blocks were transported or formed by natural means, whereas the blocks MQ 1b-4, originally construction material, were moved by man.

MQ-1b-1

This type of quarry exploited millstones from large surface blocks accumulated in taluses at the base of cliffs or sharp slopes (fig. 6.4). These sites comprise multiple blocks allowing for a large production. Examples of this production are a sector of Moclín (GR-1b), Castillo de Locubín (J-1) and Vélez de Benaudalla (GR-10) (fig. 6.5).

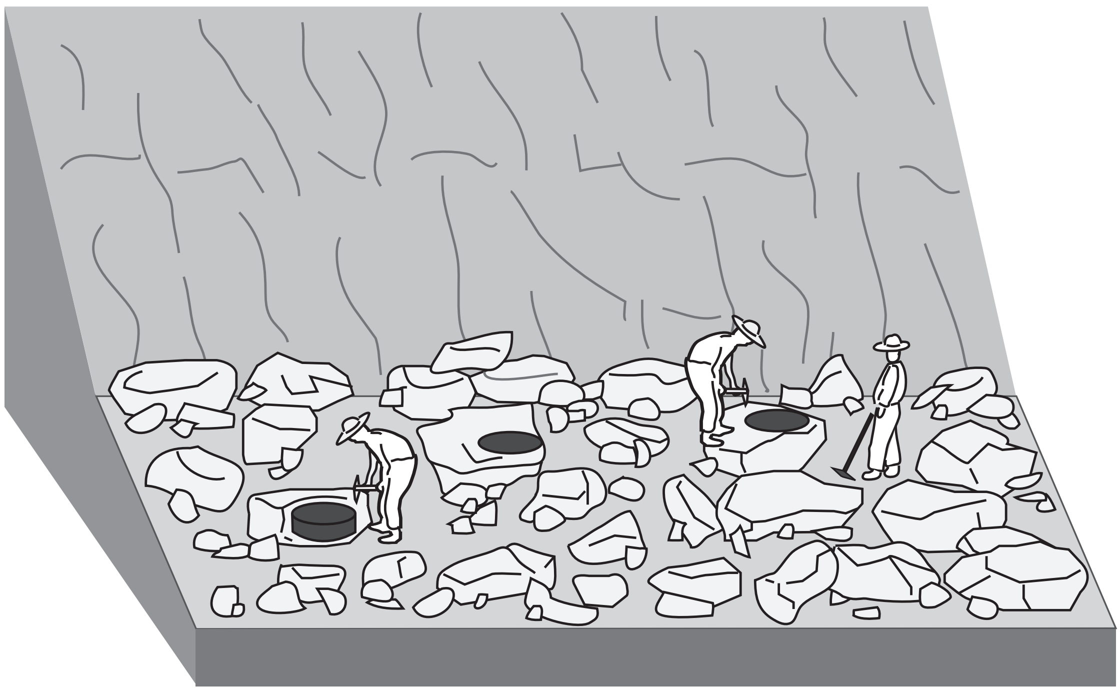


Fig. 6.4: Schematic reconstruction of a MQ-1b-1 quarry where millstones were extracted from large surface blocks, such as in taluses (drawing by T. Anderson).

Fig. 6.5: Examples of MQ-1b-1 quarry exploiting taluses: a) Castillo de Locubín (J-1) and b) Vélez de Benaudalla (GR-10).

MQ-1b-2

This type corresponded to large single blocks transported, presumably, by landslides or other natural means (fig. 6.6) (in this study, there are is no evidence of glacial erratics). The two cases of this type, Arbuniel, Jaén (J-4) and Molino de la Piedra, Córdoba (CO-5) (fig. 6.7), were exploitations located in valley bottoms. Because of the restricted volume of the single block, these quarries, contrary to those of MQ-1b-1, could not develop into anything but modest, local productions.

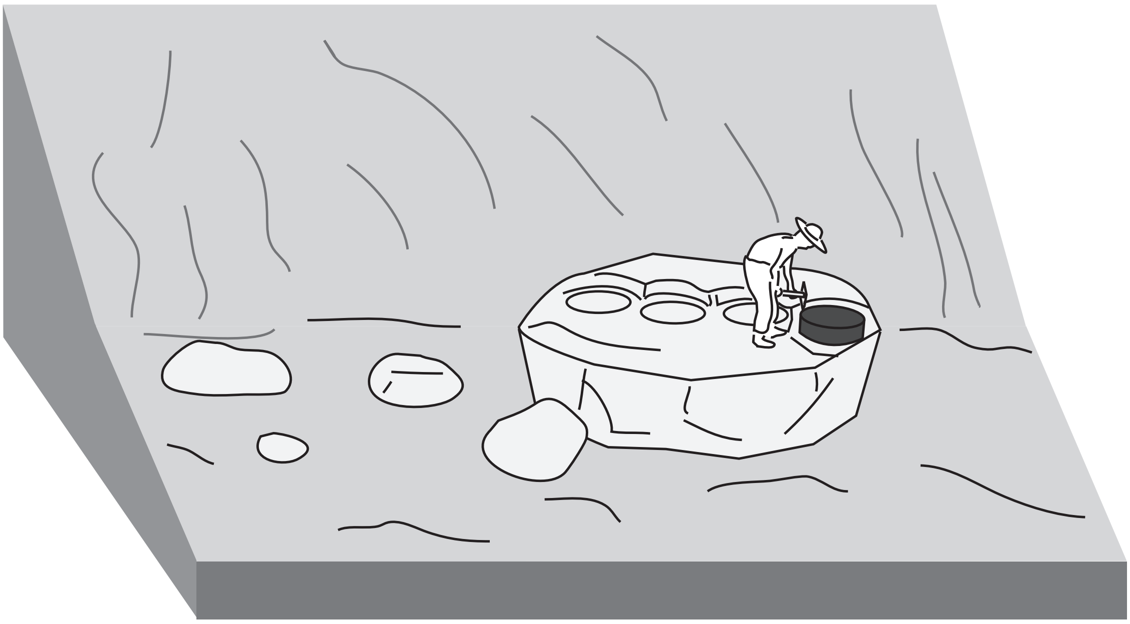


Fig. 6.6: Schematic reconstruction of a MQ-1b-2 quarry where millstones were extracted from large single blocks displaced by landslides (drawing by T. Anderson).

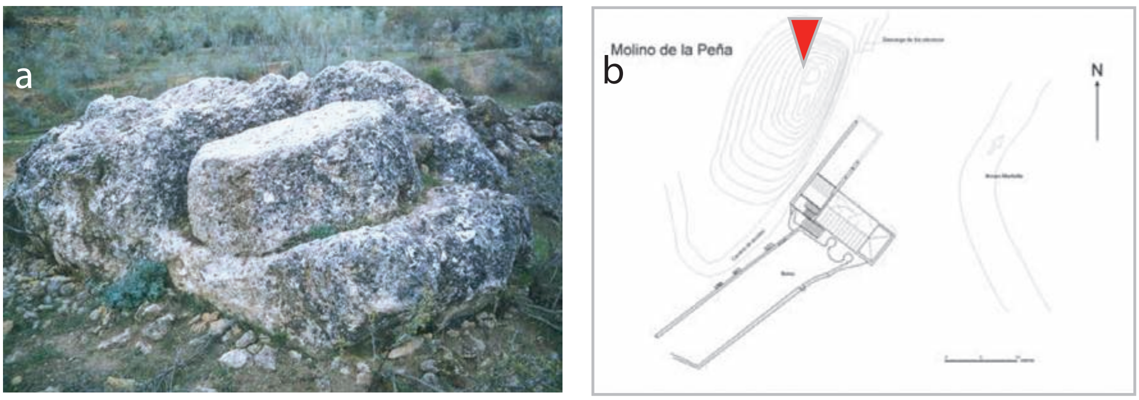


Fig. 6.7: Examples of MQ-1b-2 quarry where millstones were hewn from large single surface blocks: a) Arbuniel (J-4) (from López & Cabrera 2004) and b) Molino de la Piedra (from Córdoba de la Llave & Varela 2011: 109).

MQ-1b-3

This type of quarry exploited naturally detached, non-transported, surface blocks resulting from erosion. This is the case of certain karstic landscapes where numerous *in situ* surface blocks and slabs were sculpted over time (fig. 6.8), such as El Torcal (MA-1), Teba (MA-2), Sierra de Utrera (MA-8) and Fuensanta, Loja (GR-2) (fig. 6.9). This type also applies to the certain granite fields where naturally rounded surface boulders (*piedras caballeras* or *tolmos*) were exploited, such as at Miraflores de la Sierra (M-5). These sites also differ from the MQ-1b-1 type in that they are much more extensive and can develop into very large productions. The case of the schist quarry of El Campillo Viejo (HUE-1), also of this type, is slightly different. These surface blocks were not rounded by erosion but were broken up into slabs, presumably by tectonic movements.

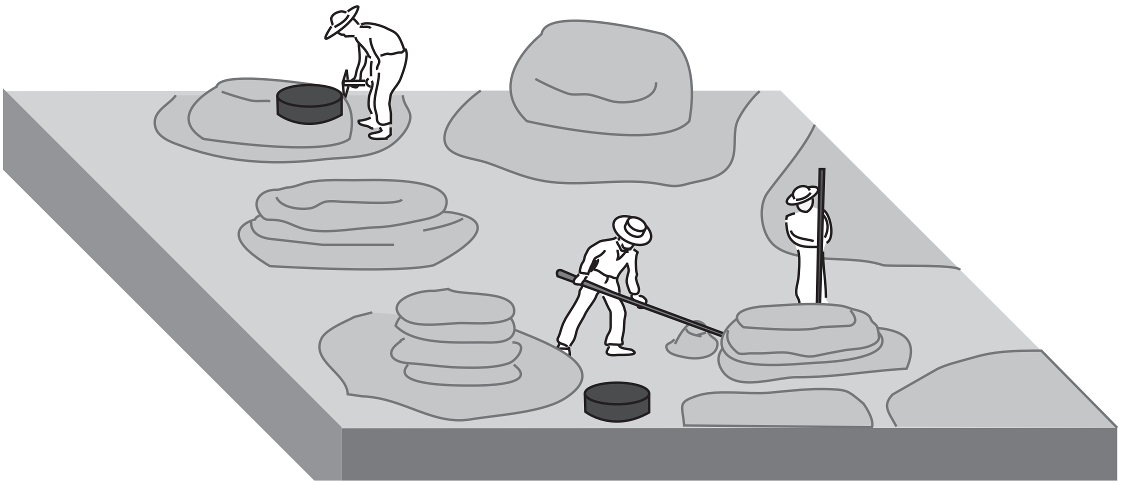


Fig. 6.8: Schematic reconstruction of a MQ-1b-3 quarry where millstones were scored from large, naturally detached, non-transported slabs formed by erosion. These exploitations took place, for example, in karstic limestone and granitic boulder landscapes (drawing by T. Anderson).

Fig. 6.9: Example of a MQ-1b-3 millstone quarry: The karstic landscape of the in the Natural Park of El Torcal (MA-1) comprises numerous naturally sculpted and detached surface blocks and slabs that were well-suited to be hewn into millstones. a) general view; b) detail.

MQ-1b4

This quarry type differed from the previous three in that is exploited recycled material from man-made features (fig. 6.10). Only a few of these sites have been identified in southern Spain. The most notable example is an unfinished Pompeian upper stone at the Roman city of *Baelo Claudia* (CA-2) (fig. 6.11), probably hewn from a recycled bio-calcarenite ashlar or column drum. Drum segments from the Roman quarry of Cerro Bellido (SE-4) are also reputed to have been recycled into millstones in the Middle Ages. An excellent example of this is beyond the Spanish border, at Chardy (Orsennes), France, where the table top of a dolmen was being carved into a millstone (Gérard Coulon, Database Meulières.eu, no. 159).

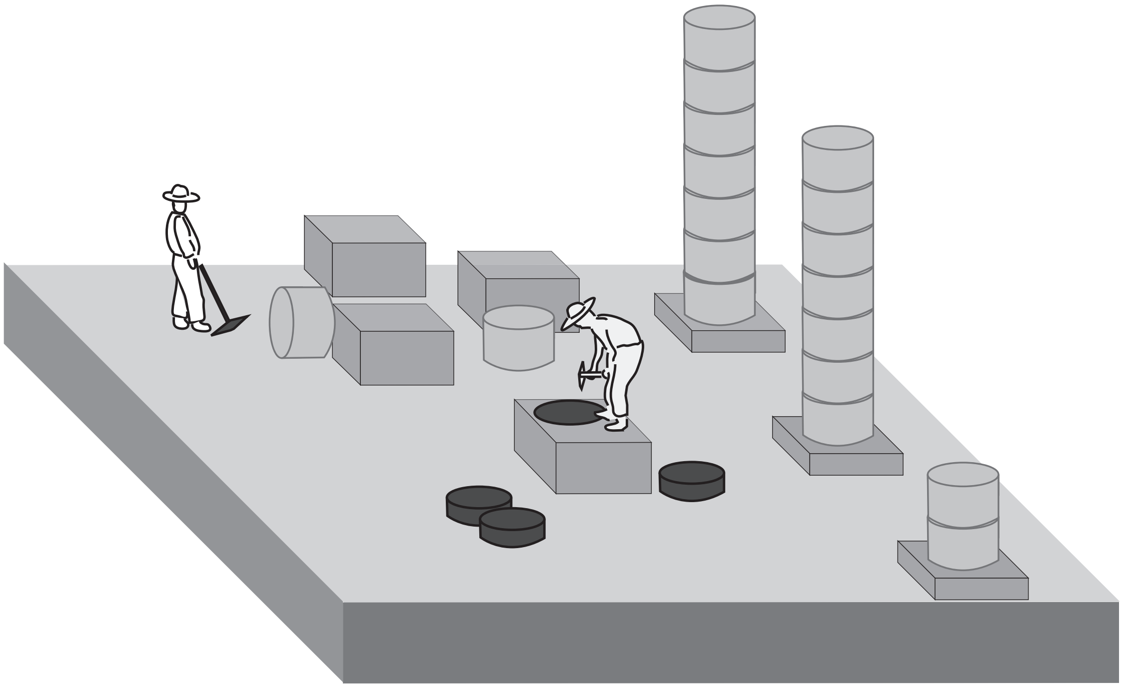


Fig. 6.10: Reconstruction of a MQ-1b-4 exploitation where millstones were hewn from recycled construction material (drawing by T. Anderson).

*Fig. 6.11: Example of an unfinished Pompeian millstone (*catillus*) recycled from an bio-calcarenite ashlar or column drum. The rock is probably originally from a nearby quarry such as Punta Camarinal (CA-2a) of Punta Paloma (CA-2b).*

6.2. Bedrock millstone quarries (MQ-2)

The second major category of quarries, those exploiting bedrock, is divided into true extractive sites where cylinders were scored directly from bedrock (MQ-2a) and exploitations where angular blocks were first detached (following natural fissures) before being fashioned into millstones (MQ-2b). Each of these major types can be subdivided according to morphological criteria.

6.2.1. True extractive quarries (MQ-2a)

In true extractive millstone quarries (the term is borrowed from Runnels 1981: 72), cylinders were scored directly from bedrock by means of trenching resulting in characteristic circular extractive hollows. Cutting directly into the heart of the rock required specific skillls and tools, in particular the pick. These workings, in favourable conditions of conservation, resulted in numerous tool marks on both the quarry faces and the quarry floors.

Multiple, superimposed extractions, like a stack of coins, took place mostly on horizontal (or slightly inclined) extractive planes following the rock's natural bedding and resulting in vertical tubular faces (fig. 6.12). This type, labelled MQ-2a, is represented, among others, by the sites of Los Guillares, Padul (GR-7), Montesa, Valencia (V-2) (fig. 6.13), Los Frailes, Cabra (CO-1) and Moclín (GR-1) (fig. 6.14).

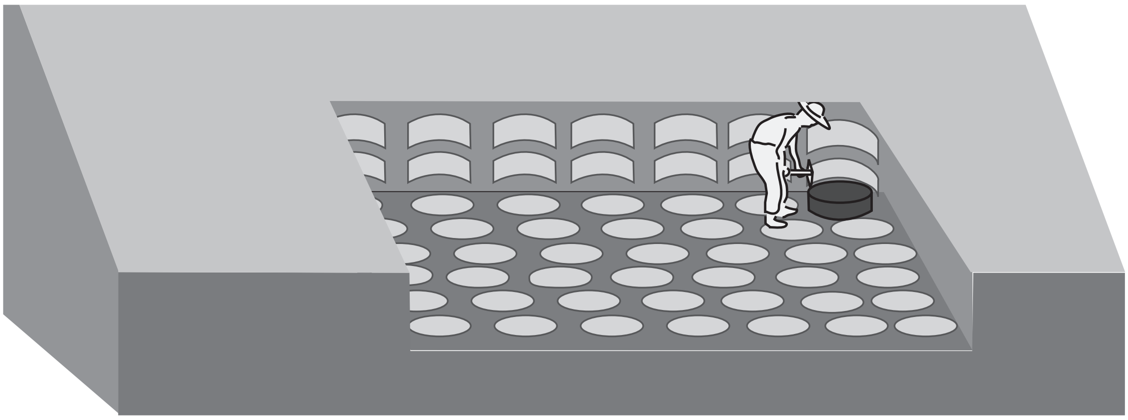


Fig. 6.12: Schematic reconstruction of a true extractive millstone quarry (MQ-2a) where horizontal scoring produced quarry faces with superimposed, tubular-shaped hollows (drawing by T. Anderson).

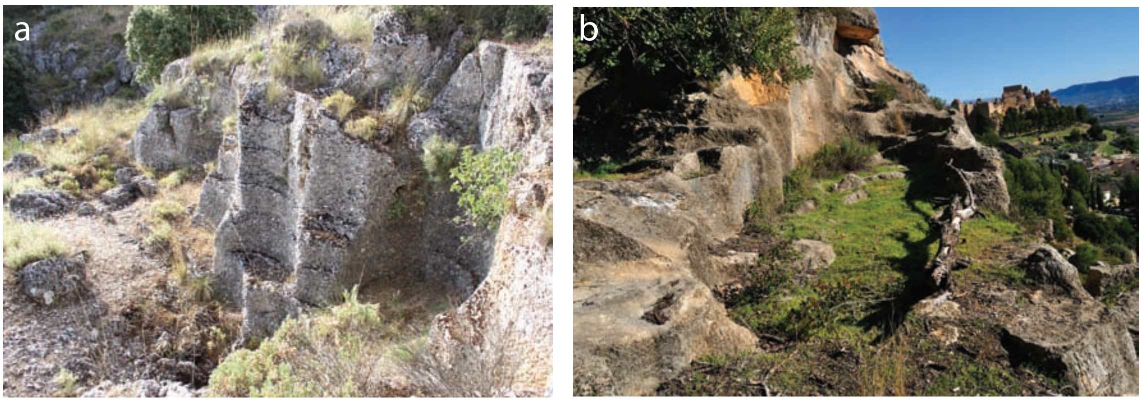


Fig. 6.13: Examples of true extractive millstone quarries with high vertical tubular faces (MQ-2a): a) Los Guillares, Padul, Granada (GR-7) with up to 6 levels of extraction and b) Montesa, Valencia (V-2).

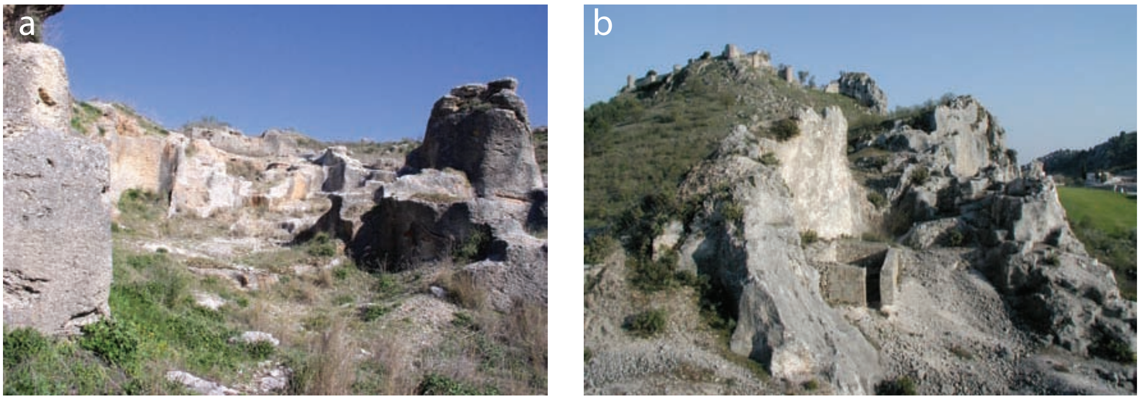


Fig. 6.14: Examples of true extractive millstone quarries with high vertical tubular faces (type MQ-2a): a) Los Frailes, Cabra, Córdoba (CO-1); and b) Moclín, Granada (GR-1).

An alternative form of this quarry type is when an extraction took place along vertical (or sharply inclined) planes, perpendicular to the rock's bedding plane (MQ-2a2) (fig. 6.15). This required a particularly compact rock that would not fracture along its original horizontal bedding plane. Only five sites in our study made use of this technique: Castillo de Locubín, Jaén (J-1), Barranco de los Molinos, Ibi (A-2), Vélez de Benaudalla (GR-10), Los Guillares, Padul (GR-7) and El Campillo (HU-1) (fig. 6.16). It must be noted that the opposite horizontal extractions prevail at all of these sites, except for El Campillo.

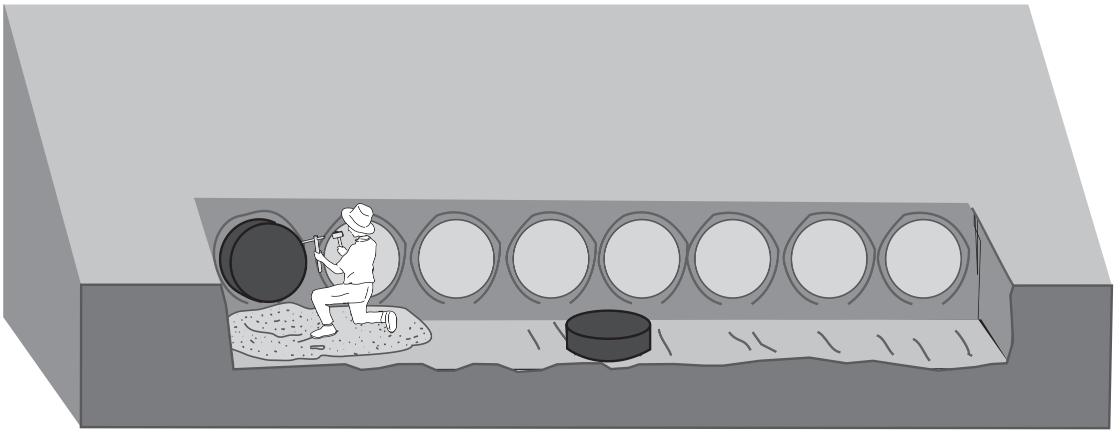


Fig. 6.15: Schematic reconstruction of a true extractive quarry scoring millstone along vertical planes (MQ-2a2) resulting in quarry faces with vertical extraction hollows (drawing by T. Anderson).

Fig. 6.16: Examples of vertical extractions: a) Los Guillares, Padul, Granada (GR-7) and b) El Campillo, Huelva (HU-1).

6.2.2. Block detachment quarries (MQ-2b)

Block extraction quarries differed from true extractive quarries in that the material detached from the rock mass were angular blocks and not cylinders. This was carried out with levers and crowbars, profiting from natural fissures, as opposed to scoring directly into the rock by cutting trenches. The quarry faces of these sites were therefore not "tubular" but "planar" or irregular with few, if any, tool marks (fig. 6.17) and can be confused with natural mechanical processes that break up rock, such as gelifraction. Although the basic instrument was the lever, picks and chisels were used at times to carve cavities into the fissures to facilitate the insertion of the lever. Although extraction took less time than cutting bedrock, the subsequent fashioning phase was longer since a larger quantity of mass had to be removed to obtain a cylindrical form.

An example is Fuente de los Morales near Alhama de Granada (GR-6) (fig. 6.18a) where large blocks were pried out from a distinct layer of white limestone. This technique was also used at certain sectors of the Roman quarry of Cerro de Limones (AL-1), where small blocks were pried from the top of volcanic columnar jointing. Some of the millstones at Miraflores de la Sierra (M-5), in the granite fields of the Sierra de Guadarrama, were also carved from previously detached angular blocks (fig. 6.18b).

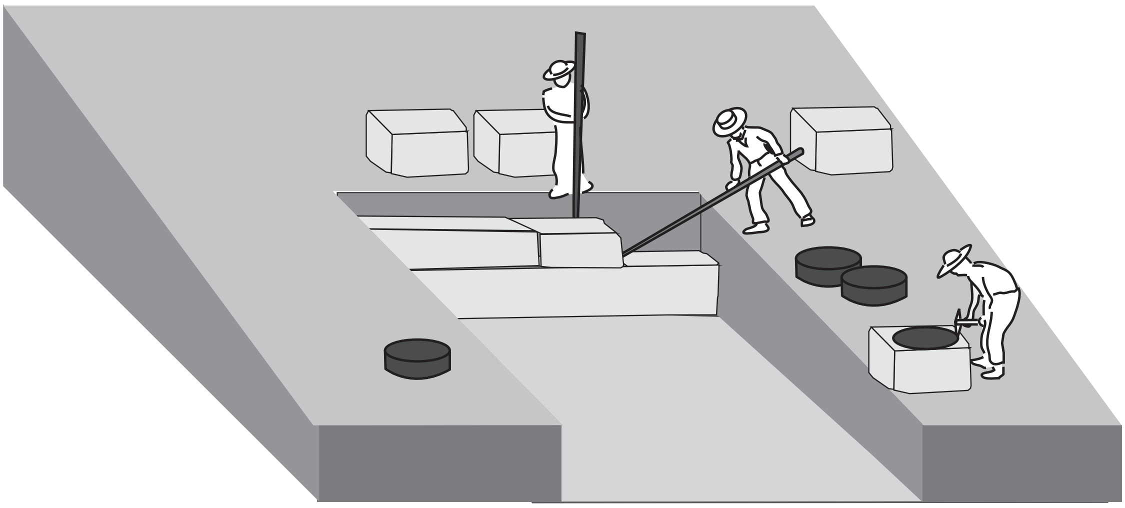


Fig. 6.17: Schematic reconstruction of a MQ-2b1 millstone quarry where angular blocks were detached along horizontal planes before being carved into millstones (drawing by T. Anderson).

Fig. 6.18: Examples of quarries where angular blocks were detached from the bedrock for millstone production: a) Fuente de los Morales, Alhama de Granada (GR-6); and b) Miraflores de la Sierra (M-5) (photograph left by Fernando Colmenarviejo).

6.3. Mixed exploitations: surface block and bedrock quarries

Not all millstone quarries can be comfortably classified into the models presented above. A number of these show that the workers modified and adapted their techniques to different topographical features. Roman quern makers at the Cerro de Limones (AL-1) exploited both loose surface blocks in the talus and columnar jointing. The *moleros* of El Campillo (HU-1) had the choice of surface blocks or bedrock (fig. 6.19 a-b), whereas at Castillo de Locubín (J-1), they could chose between large surface blocks in the talus, cutting cylinderes directly into the bedrock or detaching angular blocks with levers (fig. 6.19 c-f).

Fig. 6.19: Example of quarries with mixed extraction techniques: a-b) El Campillo Viejo (HU-1): a) loose surface block exploitation; and b) vertical bedrock outcrop extraction; c-f) Castillo de Locubín (J-1): c) unfinished cylinder carved from a surface block in the talus; d) vertical extraction cut directly from bedrock; e) "planar" quarry face (lighter colour) where blocks were detached along natural fissures; f) The natural stratification of the rock of the abandoned millstone (arrows) indicates a vertical extraction. The absence of vertical extractions in this sector of the quarry, suggests this cylinder was hewn from an angular block detached from the adjacent quarry face (photographs a and b by Alonso García Veiga; c-f by T. Anderson).

6.4. The morphology of extractive millstone quarries

Independent of the extractive techniques, bedrock millstone quarries (MQ-2a and MQ-2b) take on different forms depending on the features of the terrain, their size and depth, open-air or subterranean, their direction of progression, the inclination of the rock layer, the accessibility and thickness of the desired layer, and whether the extractions are contiguous or not. Some of the larger quarries are difficult to classify from a morphological point of view because they integrate different methods of work and different topographical features. The following designations, with terms at times borrowed from construction quarries (notably Bessac 2003), are meant to facilitate the general description of millstone quarries.

6.4.1. Bench quarries

Bench quarries (fig. 6.20) advance perpendicularly into the heart of the slopes of hills and mountains and are the result of a contiguous extractive process with a forward and lateral progression. These sites, among the most common in our study area, are basically U-shaped with rectangular-shaped faces and triangular-shaped walls. They are both deep and shallow. Los Frailes, Cabra (CO-1) and at certain sectors of the sites of Peña Harpada (CA-10), Zagra (GR-5) (fig. 6.21) and Loja (GR-5) are examples (fig. 6.22). The term "bench" alludes to the general shape of the quarry and should not be confused with the identical term that defines the steps (tiers) between different levels of quarry floors.

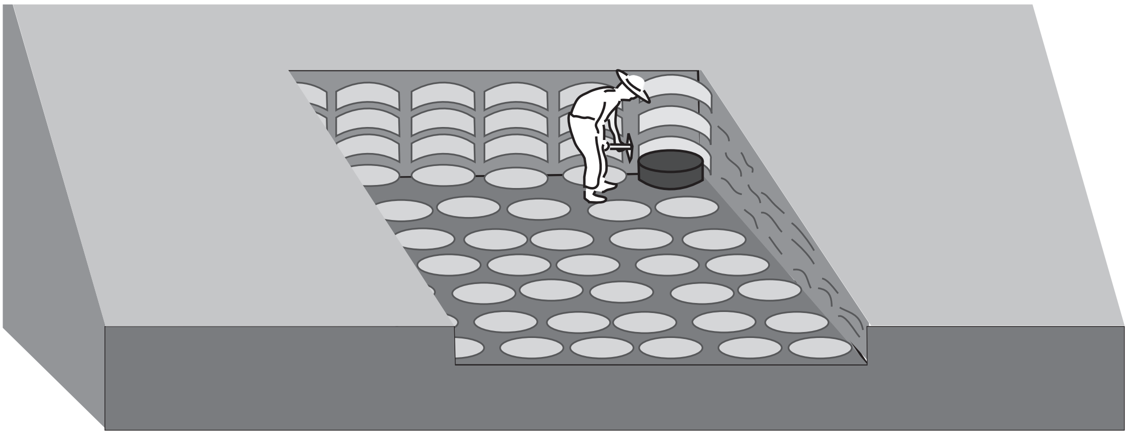


Fig. 6.20: Schema of a bench millstone quarry (drawing by T. Anderson).

Fig. 6.21: Example of a bench millstone quarry at Zagra (GR-5).

Fig. 6.22: Example of a bench millstone quarry at Loja, Cerro Fuensanta (GR-3).

6.4.2. Pocket quarries

Pocket quarries (fig. 6.23) are simply smaller versions of bench quarries. Instead of extracting in one single location, resulting in a large bench quarry, these exploitations are spread out over the slope of the hill or mountain. These different workings suggest concessions to different teams. At times they present a slight overhang, as it they were going to pursue their progression underground. The best example is the Hacho quarry near Lora de Estepa (SE-3) (fig. 6.24).

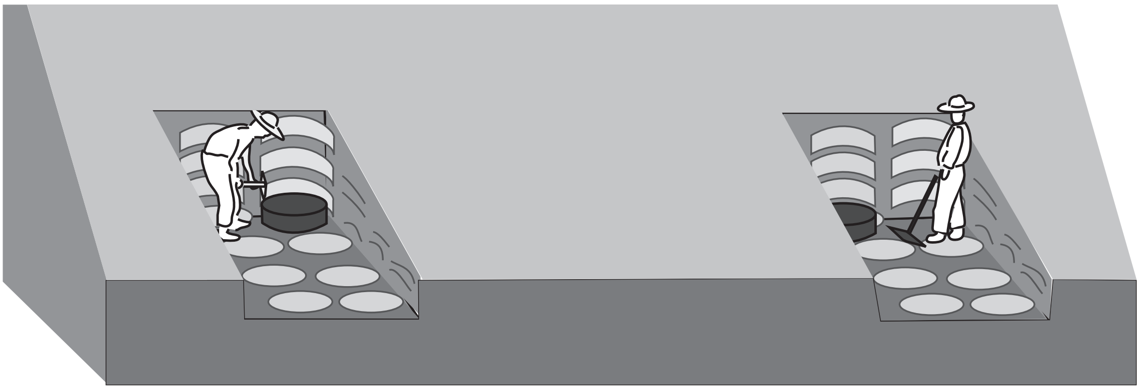


Fig. 6.23: Schema of a pocket millstone quarry (drawing by T. Anderson).

Fig. 6.24: Example of a pocket quarry. El Hacho, Lora de Estepa (SE-4).

6.4.3. Edge quarries

The factor that characterises edge quarries is the contiguous lateral progression along the edge of specific topographical features, notably cliffs, ridges and ravines. This type is opposite to that of bench quarries that progress into the heart of the slope. These quarries adopt both true extractive (fig. 6.25) and block detachment techniques (fig. 6.26). Examples are at La Merced (Gr-4c), Fuente de los Morales (GR-6) and Cudillas (CO-3) (fig. 6.27), as well as sectors of Los Guillares, Padul (GR-7).

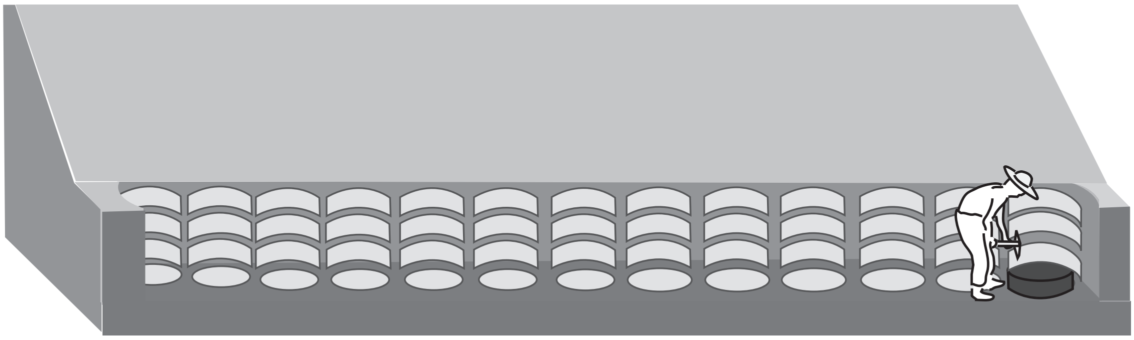


Fig. 6.25: Schema of an edge (true extractive) millstone quarry (drawing by T. Anderson).

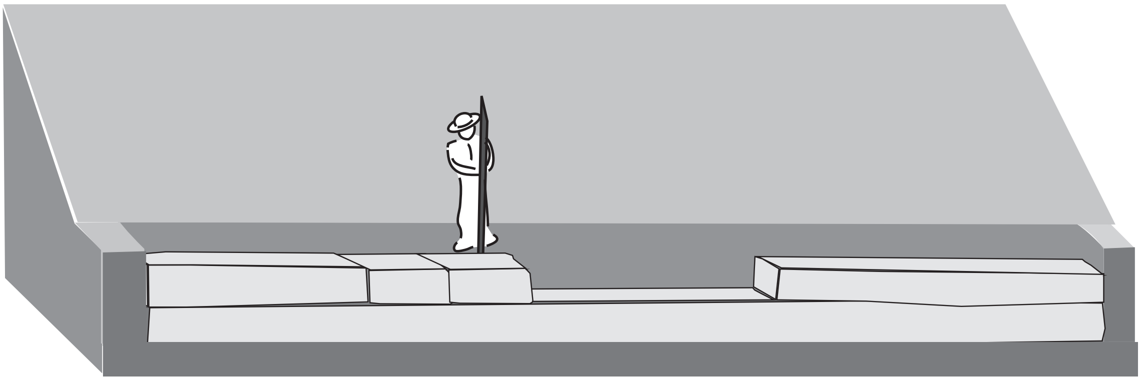


Fig. 6.26: Schema of an edge (block detachment) quarry (drawing by T. Anderson).

Fig. 6.27: Example of an edge quarry (Cudillas (CO-3)

6.4.4. Pit quarries

Pit quarries are holes dug in flat or slightly inclined terrain to attain a specific layer of rock (fig. 6.28). Their progression was both vertical and lateral. These pits were generally shallow, just deep enough to follow a desired rock layer. There are few examples in our study area. A sector on a terrace of the site of Cerro de Chispas (AL-8), today resembling a crater, attained a layer of conglomerate. The large, shallow, oval pits on the hilltop of Cerro de Limones (AL-1), now cluttered with rock debris, presumably attained the top layer of volcanic columnar jointing. The northern sector of Moclín is a deep pit that opens up to a slope where debris was cleared (fig. 6.29).

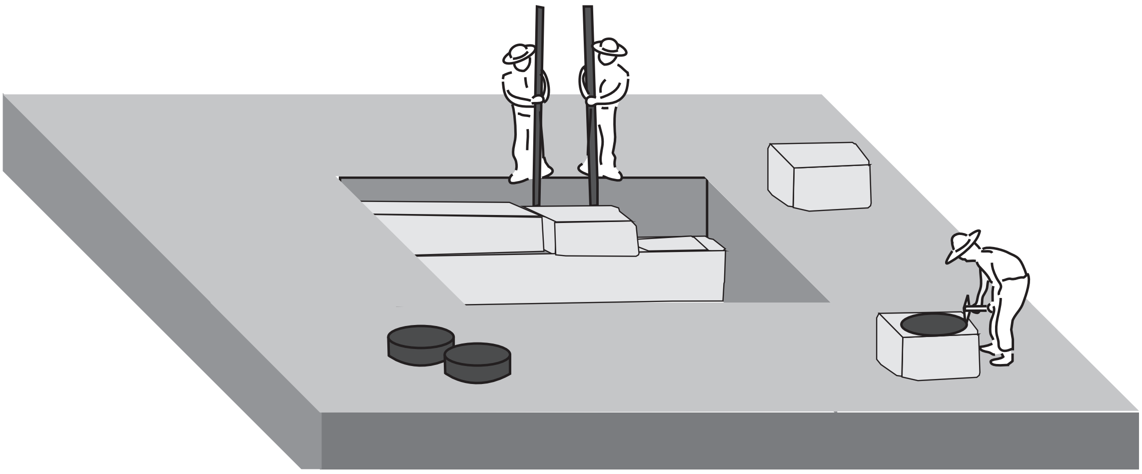


Fig. 6.28: Schema of a pit quarry (drawing by T. Anderson).

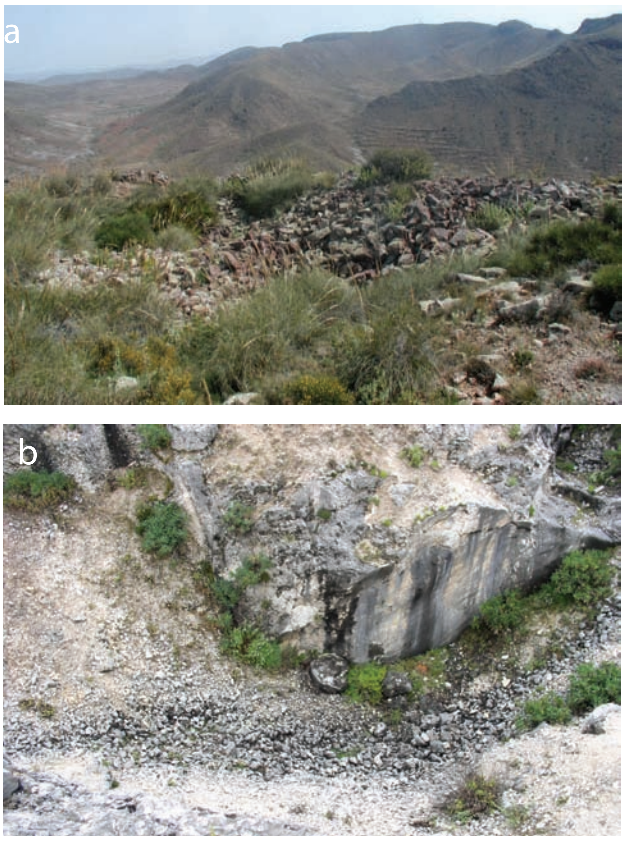


Fig. 6.29: Examples of pit quarries: a) Cerro de Limones (AL-1) and b) the northern sector of Moclín (GR-1).

6.4.5. Trench quarries

Trench quarries are characterised by a narrow, linear and forward progression (fig. 6.30). These sites, comprising at times more than one trench, are found in flat or nearly flat terrain. In our study area there are two examples, Cantera de la Rambla (GR-11) near Caniles, and Lachar (J-2) by Jimena (fig. 6.31), exploiting respectively conglomerate and limestone. Besides their long parallel trenches, these sites are also characterised by elongated cordons of working debris set to each side of the trenches.

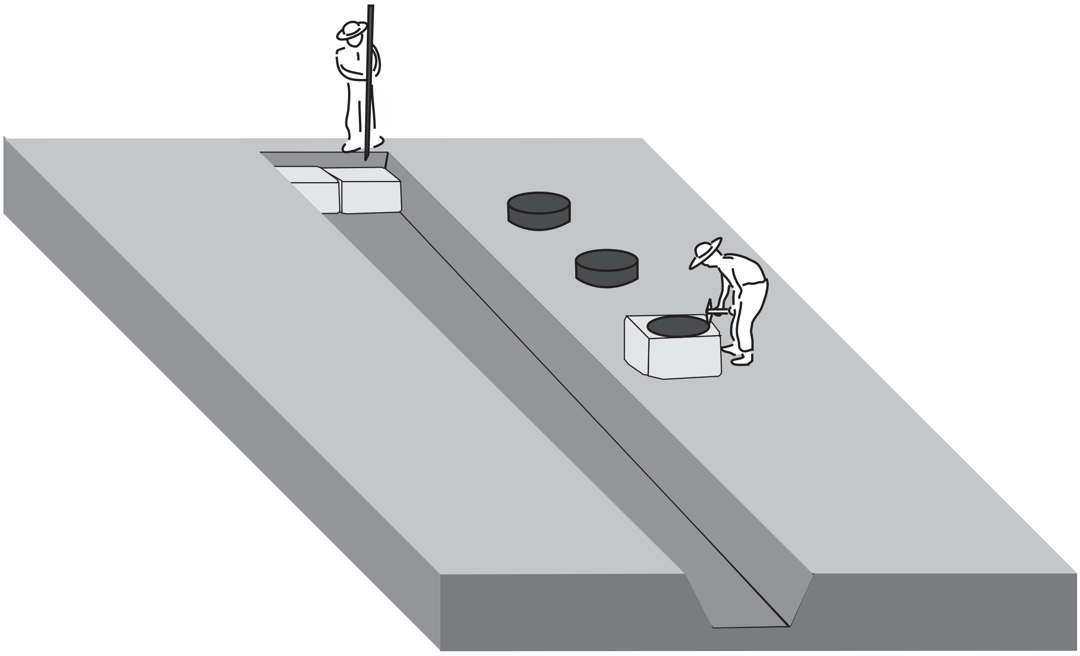


Fig. 6.30: Schema of trench millstone quarry (drawing by T. Anderson).

Fig. 6.31: Example of a trench quarry, El Lachar, Jimena (J-2).

6.4.6. Extensive contiguous shallow quarries

Extensive shallow quarries are exploitations where the bedrock stretches out over a large area and is at surface level or below a thin layer of topsoil. Contiguous extractions, instead of progressing vertically, progress in all directions (fig. 6.32). Millstone makers simply advanced along the surface without having to confront the complications inherent to multiple level extractions (in particular the problem of removing debris). These sites, of varying size, do not always have clearly defined boundaries, especially when partially covered by topsoil. Examples include the coastal sites of Trafalgar (CA-1) and Playa de Carchuna (GR-9), the hill sites of Las Calzadillas 1 (SE-1a), Guajar Faragüit (GR-8), Puerto de la Cadena (MU-1) and the upper sector of the Rambla Honda (AL-3a) (fig. 6.33).

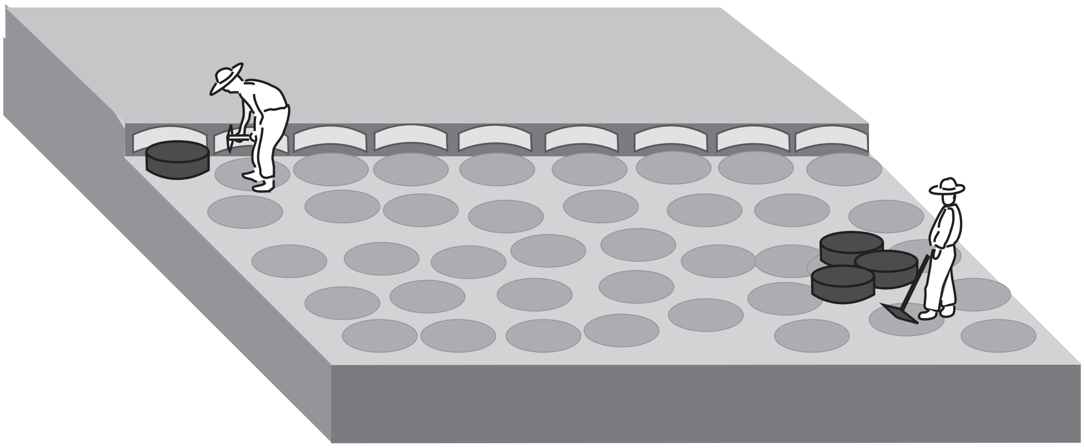


Fig. 6.32: Schema of an extensive shallow millstone quarry (drawing by T. Anderson).

Fig. 6.33: Example of extensive shallow quarries. A) Puerto de la Cadena, Murcia (MU-1) and b) Cantera de la Rambla Honda (AL-2).

6.4.7. Extensive dispersed quarries

Extensive dispersed quarries correspond to sites where the millstone makers exploited a number of small, dispersed outcrops. Work at each outcrop was always shallow and usually comprised a handful of extractions or, more rarely, a single extraction. Distances between the different sectors varied, with intervals of up to 50 m to 100 m. Borders are ill-defined. These differ from pocket quarries in that extractions are always limited to one level. The most characteristic extensive dispersed quarries are in karstic limestone landscapes or granite units. Examples are at El Torcal (MA-1), El Tajo, Teba (MA-2), Camino del Calvario, Loja (GR-3) (fig. 6.34), and the granite fields at Miraflores de la Sierra (M-5) and Guijo de Galisteo (CC-5) (fig. 6.35).

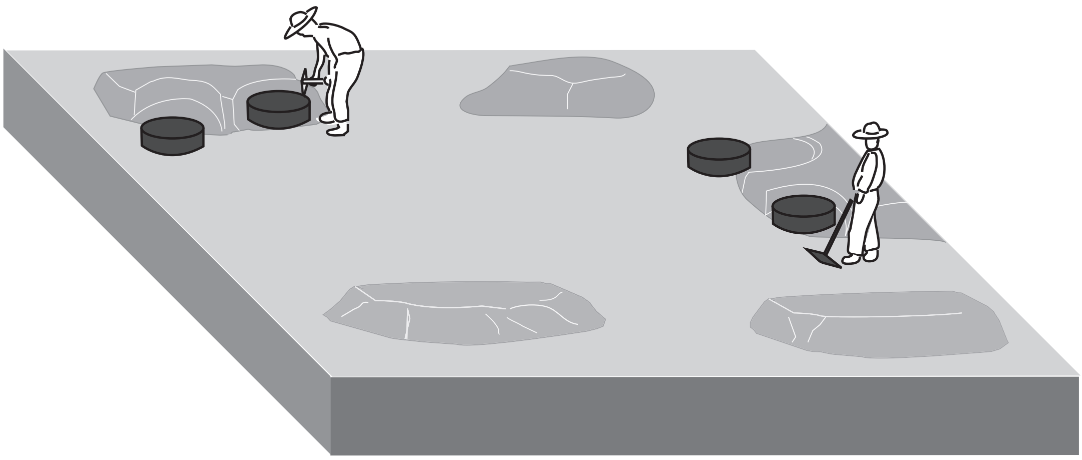


Fig. 6.34: Schema of an extensive dispersed quarry (drawing by T. Anderson).

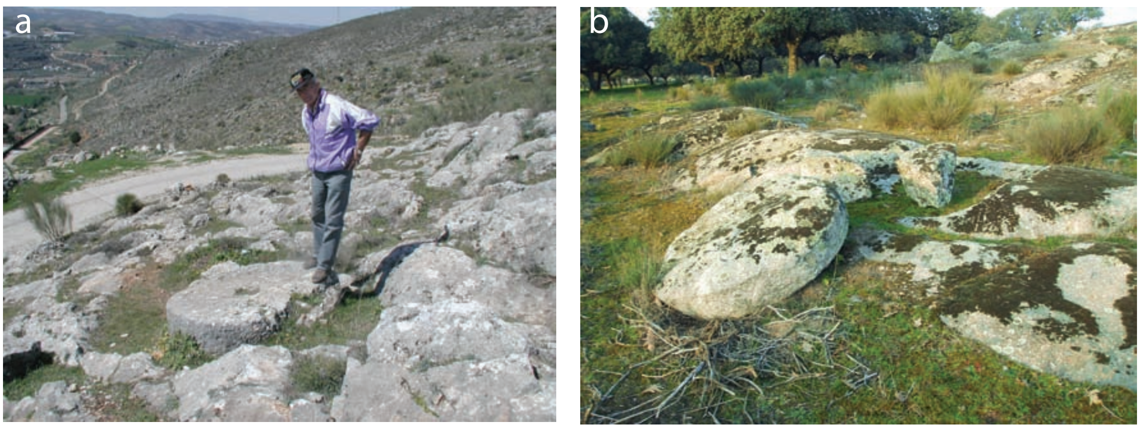


Fig. 6.35: Example of multiple outcrop quarries: a) Camino del Calvario, Loja (GR-3), worked karstic outcrops, and b) Guijo de Galisteo (CC-5), worked granite outcrops.

6.4.8. Subterranean quarries

Subterranean millstone quarries are caverns (most often artificial) resulting from a concentration of extractions scored from the flank of a hill or mountain. To follow a specific layer of stone, millstone makers were obliged to pursue their work underground, as overlaying levels of overburden and rock were too voluminous to remove (fig. 6.36). La Merced (GR-4b) in Loja is the only subterranean quarry identified our study area (fig. 6.37). This is surprising considering the long tradition of underground mining in Spain

A subterranean exploitation is known accross the Strait of Gibraltar at the Cave of Hercules near Tangiers (Morocco). The late millstone specialist, Cecil Curwen, visited it in 1956, and actually witnessed quern extraction by candle light (Williams & Peacock 2011: vii). In France several subterranean *meulières* are known, notably at the Mont Vouan (Haute-Savoie), the object of recent archaeological work under the direction of A. Belmont. In Germany, the best known are in the Eifel, where volcanic millstones were scored in kilometres of underground galleries (Harms & Mangartz 2002).

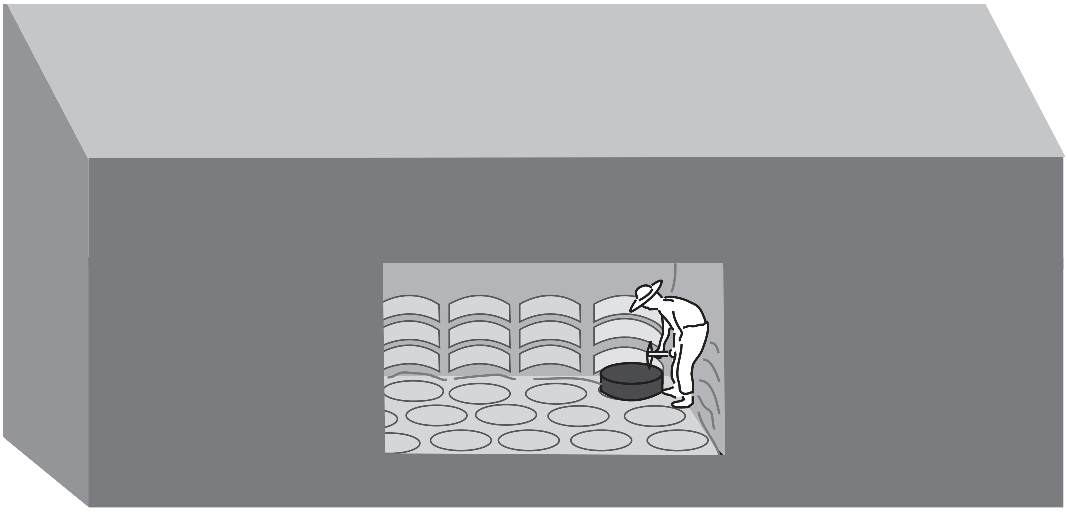


Fig. 6.36: Schema of a subterranean millstone quarry (drawing by T. Anderson).

Fig. 6.37: The small exploitation at La Merced (GR-4b) is the sole subterranean millstone quarry identified to date in the south of Spain. In the picture to the right the compact layer (a) exploited for millstones contrasts with the overhanging, britle rock (b).

6.5. Quantifying the types of millstone quarries

6.5.1. Surface block and bedrock quarries

Of the total millstone quarries (133) presented in the catalogue, about half (70) can be classified into four main types (fig. 6.38). Some of these are represented more than once. The rock material at Castillo de Locubín (J-1), for example, presented itself in the form of large surface blocks and bedrock exploited both in with the true extractive and block extrathree different extraction methods and hence falls into three different categories.

On the whole, it is clear that bedrock quarries made up of true extractive quarries (MQ-2a, 46 cases) and block detachment quarries (MQ-2b, 14 cases) make up the majority of the millstone quarries. Quarries exploiting surface blocks (MQ-1a, 2 cases; and MQ-1b, 8 cases) are in clear minority. Only two sites, the volcanic quern quarries of Almería (AL-1 and AL-2) show evidence of the knapping of small surface blocks (MQ-1a). The main extraction method of these sites, almost double that of all the other categories combined, and corroborated since Roman times or earlier was that of true extraction. This reflects the abundance of extensive homogeneous rock outcrops suitable for millstone production.

The domination of bedrock quarries (MQ-2) over quarries exploiting surface blocks (MQ-1) has to be qualified. About half of these large loose block sites, such as Moclín, Las Pedrizas (GR-1b), Castillo de Locubin (J-1) and Vélez de Benaudalla (GR-10) are secondary talus workings in the framework of larger bedrock exploitations. Since they are incidental to the larger bedrock workings, their small number seems to reflect a reality. The minute number of MQ-1a sites, by contast, as we have noted, certainly does not reflect the real number of these quarries, that do not leave perceptable evidence in the field.

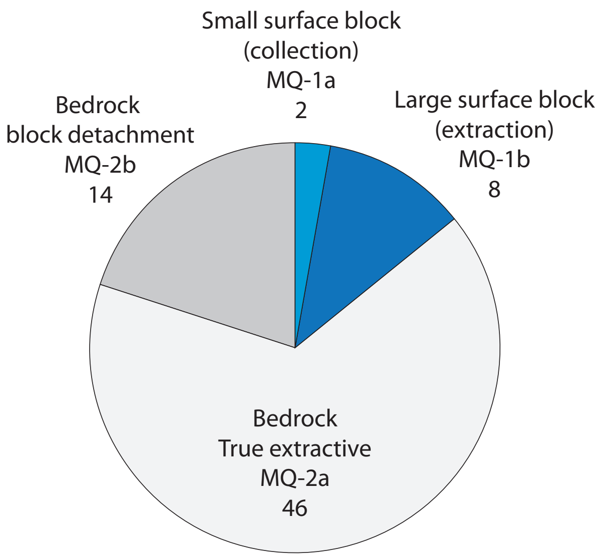


Fig. 6.38: Pie chart indicating the proportions of the different categories of millstone quarries. Bedrock exploitations (grey hues), dominate by far those of surface block exploitations (blue hues).

6.5.2. Quantifying the morphology of millstone quarries

Only 56 of the 133 sites could be placed into one or more of the eight morphological classes that have been defined. The physical shape of these sites is, on the whole, homogeneous. Only a few sites, for example, Los Guillares (GR-7) that has both "edge quarry" and "bench quarry". sectors.

From the graph (fig. 6.39) we can assume that Bench and Extensive Shallow workings together make up about half of the sites. The Bench type points to quarries on slopes that cut directly into the bedrock, one of the more common means of exploiting rock, as in construction quarries. It permits working in a restricted space and although debris is relatively easy to manage, the volume of overburden that has to be evacuated can increase as work progresses. Extensive shallow quarries are found in large expanses of bedrock. Here debris is not a problem since it can be placed adjacent to the extractions. These are followed by Extensive dispersed, Edge and Pit quarries. Extensive dispersed quarries reflect surface workings along karstic and granite fields, geological units that are widespread in certain areas of the south of Spain. Edge quarries reflect a row of extractions along ridges and ravines where the bedrock was exposed. Pit quarries, also a very common type among construction workings, are not very common in millstone workings. In the Roman and earlier times these workings were relatively shallow and the desired layer of rock was relatively easy to attain. In more recent times, this type required a complex infrastructure to evacuate debris and remove the heavy millstones and would therefore have been limited to large productions, such as the deep granite pits of Gerena (SE-7) in Seville. No quarry districts in our study area resemble the fields of pits that were dug in the area of La Ferté sous Jouarre, France, to extract blocks of siliceous *meulière* rocks required digging deep pits that were constantly being flooded by groundwater.

Pocket, Trench and Subterranean quarries are less frequent. Multiple Pocket sites, small versions of bench quarries, as we have noted, could reflect concessions to different teams. Trench quarries lend themselves to following a specific layer of rock that is covered by soil. Parallel trench quarries could also reflect concessions to different teams. There is only one subterranean quarry in our study area, which is surprising, owing to the long tradition of underground mining in Spain.

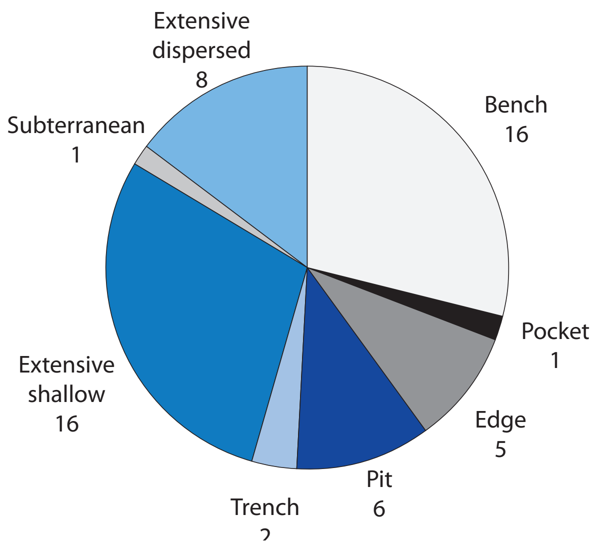


Fig. 6.39: Pie chart indicating the different proportions of the eight morphological classes of millstone quarries.

7. MILLSTONE QUARRY TOPONYMY

The study of place names is a valid and recognised means of acquiring information about ancient millstone production. In France, the names *Molière* and *Moulière* and a number of derivatives rooted from the Latin "*mola*" (meaning mill) account for the identification of a large number of millstone production sites. In the former French Province of Dauphiné alone, there are 68 cases, some as old as the 13th and 14th centuries (Belmont 2006, Vol. 1: 56-59). A recent study has corroborated the utility of place names in north-central Spain to identify millstone quarries. The name *Molares*, deriving from the Latin *mola*, has proven to coincide with a number of these exploitations in La Rioja and parts of Castilla León (Pascual & Ruiz 2011: 285-286).

Although we have applied these analyses to our research in the south of Spain, the results of *Molares* place name searches has not been as conclusive as in France or northern Spain because the term and its derivatives often have other connotations. A second term, *cantera*, meaning simply "quarry", although related at times to millstone production, more often denotes building material workings. There are other names such as *piedra* (rock) or *berruecos* (granite rock) that also, at times, coincide with millstone workings.

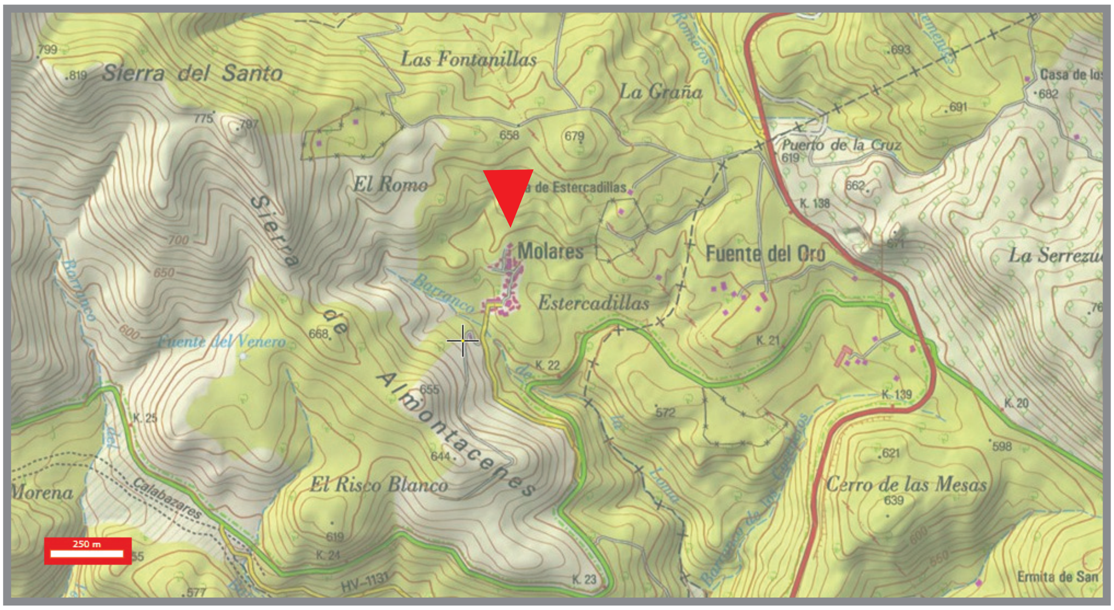


Fig. 7.1: The location of the place name Los Molares*, a hamlet in the Municipality of Almonaster la Real, Huelva. This is the only example of the name* Los Molares *that is directly related to a millstone quarry (extract from SIGPAC).*

7.1. *Molares* and its derivatives

Three sites in our study area are linked to the *Molares* place name and can be unequivocally linked to millstone production. These are found in the municipalities of Almonaster la Real, Huelva (HU-8), Molares in Cuenca (CU-1) and Sienes in Guadalajara, at the hamlet of Tobes (GUA-05) (fig. 7.1).

The derivatives *Moles*, *Mola, Molar*, also at also times linked to millstone production. This is the case of the sites of Canals (V-1), Montesa (V-2), Fuentealbilla (AB-1), Barranc de l'Escuera (A-1), Llerena (BA-2) and Hornachuelos (CO-13). The variant *Piedras Moleras* (literally "millstone rocks") on the outskirts of Villanueva de Córdoba (CO-11), is highly evocative of millstone workings (fig. 7.2). Although granite block quarries are known around Villanueva de Córdoba, and Roman and Medieval granite querns and millstones are deposited in the local museum, the quarries are yet to be identified in the field.

As Sans Elorza has pointed out in his recent study of mill-related toponyms in the province of Burgos, the terms *Molares*, *Molar* and *Muelas* (literally millstones) more often relate to natural topographical features, notably a butte or flat topped hill, than to millstone quarries (Sans Elorza 2012). Therefore, we are left with the doubt if the name *Moles* at Montesa (V-2), for example, refers to the flat topped hill or to its millstone production. Likewise, no millstone production has been confirmed at three locations with the *Molares* toponym, namely a town near Utrera in the Province of Seville, a valley near Rute, Córdoba and a mountain near Mazarrón, Murcia.

The case of *Mulera* by Alozaina, Málaga, is unique. Literally, the term would seem related to "mules", notably the "mule keeper". However, in this case, we suspect the term to be a variation of *Molares* due to the presence of a millstone quarry in its confines (Alozaina, MA-6).

Fig. 7.2: The place name Piedras Moleras *outside of Villanueva de Córdoba is highly evocative of millstone workings and coincides with granite workings. Millstone production, however, is yet to be confirmed (extract from SIGPAC).*

A number of other millstone sites, certified either by field work or by texts, bear the name *Morales* (inverting the "R" and the "L") which means "mulberry", a bush or tree that is common to the south of Spain. This name is, for example, linked with millstone workings on a hill above Montarrón (GUA-8), and forms part of the names of *Fuente de los Morales* by Alhama de Granada (GR-6), *Los Morales* in the area of city of Andújar (J-5) and *Vega de los Morales* in the Municipality of Priego de Córdoba (CO-4).

In the cases of Alhama and Priego where *Morales* is linked to the names fountain (*fuente*) and plain (*vega*), a botanical origin seems reasonable, in spite of the confirmed millstone workings. The inversion of the "R" and "L", however, is common in spoken Andalusian. It is therefore possible that certain *Morales* (mulberry) place names are actually *Molares* (millstone quarries). This is probably the case of Montarrón (GUA-8) where there is a clear error of transcription between the *SIGPAC* and cadastral *SEC* maps. The first is noted *Morales* while the second is written *Molares* (fig. 7.3). This discrepancy can therefore also be envisioned for other *Morales* cases.

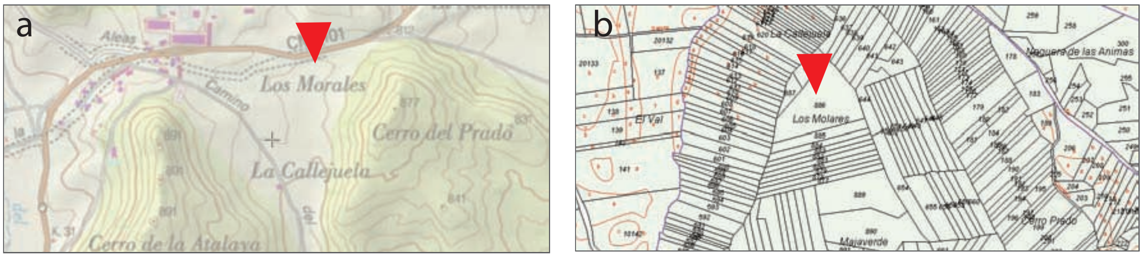


Fig. 7.3: The problem of interpreting the place name of Montarrón (GUA-8). There is a discrepancy between the first spelling "Los Morales" in the a) SIGPAC map, meaning "mulberry", and "Los Molares" in the b) cadastral map (SEC), meaning "millstone quarry".

A second *mola*-related place name, *Las Amoladeras*., is associated with the quarry of Alhama de Granada (GR-6). This name, not infrequent throughout the Spanish landscape, routinely denotes whetstone production. We cannot explain its presence in Alhama de Granada because the rock, a fine white limestone, in far from the abrasive sandstones of sharpening stones.

7.2. *Cantera* toponyms

The name *Canteras* derives from the Latin "corner" and relates to the word "quarry" coming from "squaring off". This obviously evokes rectangular building stone extraction (ashlars). The toponym in our study area is common and usually associated with construction exploitations, whether it be solid rock, sand or gravel. In the online database of toponyms of Andalusia (http://www.ideandalucia.es/nomenclator/), for example, the word *cantera* or *canteras* scored 131 hits.

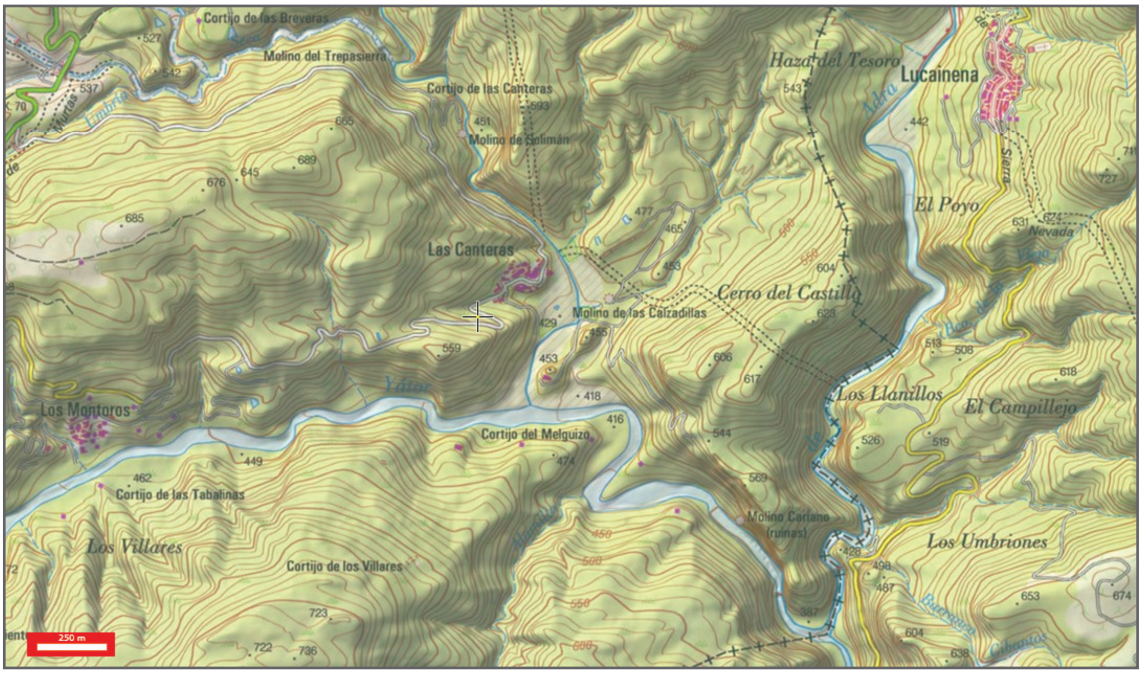


Fig. 7.4: The place name Las Canteras *near Ugíjar (GR-14) (Granada). This quarry produced both building blocks and millstones (extract from SIGPAC).).*

There are, nonetheless, a dozen cases spread throughout the landscape of southern Spain where the name is directly linked to millstone production: *Las Canteras*, Colmenar de Oreja (M-2), *Las Canteras*, Granátula de Calatrava (CR-5), *Cantera Honda*, Paterna (CO-8), *Las Canteras*, Moclín (GR-1a), *Rambla de las Canteras*, Caniles (GR-11), *Las Canteras*, Ugíjar (GR-14), *Cantera de las Pilas* (CA-9), *Las Canteras*, Castillo de Locubín (J-1), *Cantera de los Frailes*, Cabra (CO-1), *Cerro de la Cantera*, Huelma (J-3), *Las Canteras*, Guadalquitón (CA-13) and *Las Canteras*, Alhaurín el Grande (MA-3).

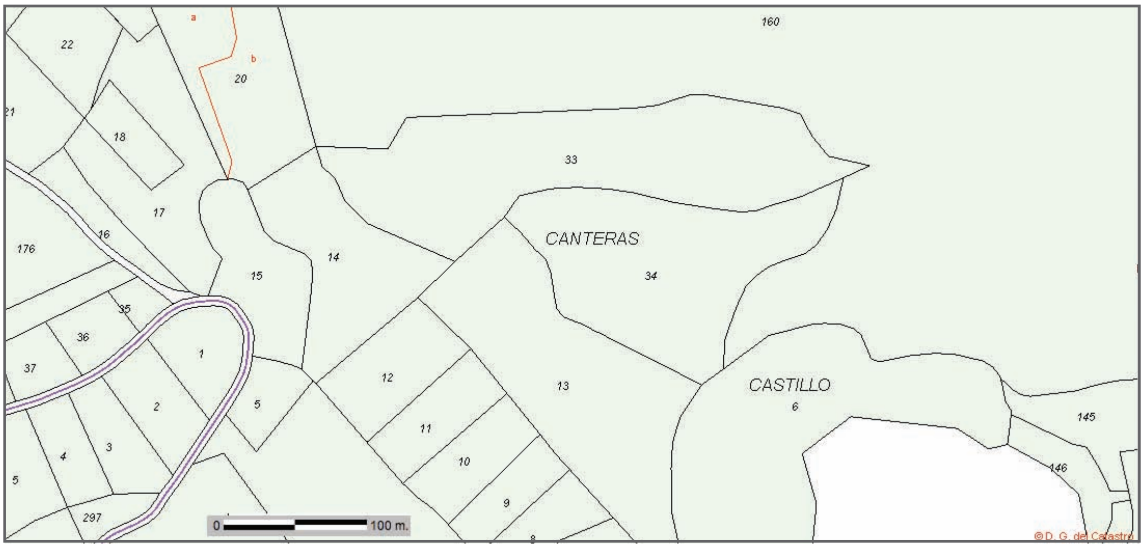


Fig. 7.5: The place name Canteras *(quarries) at Moclín (GR-1a) refers exclusively to a millstone production. There is no evidence of extraction for building material (SEC).*

At some of these sites, such as Ugíjar (GR-14) (fig. 7.4), there is evidence of both building stones and millstone workings. Other sites, however, such as Moclín (GR-1a), show no evidence of building-stone workings, proving that *Cantera* is also valid name to identify millstone production (fig. 7.5).

Other place names could be millstone related or simply coincidental. *El Tajo* at Teba (MA-2), meaning both "quarry" and "steep cliff", could either signal the millstone quarry or to the dominant topographical feature of the site. *Los Agujerones* (the "holes") near the Moclín (GR-1a), could be an allusion to the extraction hollows. *Los Cortaores* near Cabra (CO-2), meaning the "cutters", or *Barranco Baena or Pedrero* (AL-5) (*Pedrero* meaning "quarryman"), could also be linked to millstone work.

7.3. *Piedra*, *Berrocal* and other toponyms

Toponyms that are derivatives of *Piedra*, *Berrocal* and *Lanchar* (connoting rock formations), though not directly indicative of quarry work, are at times to be associated with millstone extraction.

Pedrera (from *piedra,* meaning rock) is synonymous with "quarry". In its plural form it is found outside of Alconera (BA-1) in Badajoz, and in the form of *Pedreros* (quarrymen) at Alcolea (AL-5) Almería. Other *piedra*-(rock) related names coinciding with millstone quarries are *Barranco de las Piedras* at Vélez Benaudalla (GR-10), Granada, *El Pedroso* at Andújar (J-6), Jaén, *Las Pedrizas* (GR-1b), near Moclín, Granada and *Pedrizas de Piédrola* (CR-4), near Alcazar de San Juan, Ciudad Real.

The *Berrocal* and its many derivatives is very common throughout Spain. It is a very ancient, presumably pre-Roman and has been identified in a recent article at 212 different localities throughout the Central System mountains between Madrid and the Portuguese border (Llorente 2011). It most often connotes granite outcrops, both in the form of loose rounded granite boulders and crags. In any case, the name coincides with several millstone workings in the granite fields of Madrid, around Berruecos (M-1) and Colmenar Viejo (M-3) an in Extremadura at Jerez de los Caballeros (BA-5). The *Berrueco* exploitation near Medina Sidonia (CA-8) Cádiz, one of the largest in southern Spain, is a misnomer because the rock is a white limestone, and the closest granite fields are more than 100 km away. Since this name is not common in southern Spain, it was possibly imported when the countryside was repopulated after the fall of Islamic rule.

Another rock-related name Tobes, near Siennes (GUA-5). It evokes the *toba* (limestone tufa) that was exploited for millstones around the town. Similarly, the names *Lachar* and *Lanchar* around the quarries of Jimena (J-2), Los Cortaores (CO-2) and Chapinería (M4) could relate to the exploitation of long slabs (*lanchas*).

7.4. Toponyms potentially indicative of quarry infrastructure

Some millstone workings have toponyms linked to elements of quarry infrastructure, such as roads and smithies. The association of these names with millstone workings, although hypothetical, are plausible.

7.4.1. Roads

The *Camino de las Pedreras* (road to the quarries), for example, identifies a road that connects the millstone working(s) of the Albardado Stream (CO-10) with the town of Belmez and certainly served to transport millstones to the town. Similarly, the *Camino de la Cantera* designates a road leading northwest from the Colmenar de Oreja (M-2) to the town of Chinchón. This name is more likely to derive from the transport of construction blocks destined to monumental buildings in the cities of Madrid and Aranjuez. The later millstone production would have nonetheless benefited from this thoroughfare.

7.4.2. Smithies

The name *La Herrería* of Bolaños de Calatrava, (CR-2) and *Las Fraguas* at Montarrón (GUA-8) suggests the presence of old smithies, a craft that goes hand in hand with rock work due to the necessity of repair and maintenance of the iron tools. These names are, however, incidental to sites discovered by other means.

7.5. Toponyms deriving from Arabic

Although the Islamic domination has left a strong stamp on the tradition of mills in Spain, for example in the names *aceña* for watermill, *almazara* for oil mill, *tahona* for animal-driven mill (or bakery), no Arabic toponym can be positively associated with millstone production. The closest is the *Sierra Altahona* (or *Altaona*), from *"al-Tahuna"* meaning mill (Grandal 2004: 252-253), the location of the quarry of Los Porches (MU-3). We ignore, however, if this name is linked to an old mill or if there is a connection with the millstone workings.

8. MILLSTONE QUARRY INFRASTRUCTURE

Research in southern Spain regarding millstone quarry infrastructure is nonexistent. Furthermore, old written sources, although informative about commercial transactions, never delve into how mill makers maintained and repaired of their tools, how the tonnes of stone debris were evacuated from the extraction zones, how the quarrymen were lodged, or how they transported the heavy millstones often through difficult terrain to the mill or the staging point where they were loaded onto carts or boats for their final transport. Furthermore, as we have noted in other chapters, no quarry in our study area has benefitted from an archaeological excavation that could cast light on these features of infrastructure. For these aspects we have to resort to the results of excavations elsewhere in Europe, notably Switzerland and France.

8.1. Tool repair and maintenance

The iron tools of millstone makers required constant maintenance and, at times, repair. This task had to be undertaken by a blacksmith. Although there is little direct published data related smithies in the context of millstone production, there is some evidence that suggests that they were at times located directly at the quarry. Excavations associating millstone production with smithy work are extremely rare. The most noteworthy cases are the Roman smithy of Châbles-Les Saux in western Switzerland (Anderson *et al*. 2003, chap. 6), the undated smithy at Gardom's Edge, Baslow Derbyshire in England (Radley 1964) and the 17th-century smithy of Vioménil in France (Vosges). In this last case, the smithy was built against the quarry face (see Atlas of European Millstone quarries http://meuliere.ish-lyon.cnrs.fr/php/results2.php). A recent excavation at the subterranean Grand'Gueule (Haute-Savoie) in France has also brought to light evidence (charcoal layers, smithy slag, hammer scales) of a smithy directly connected to millstone workings (Belmont & Anderson 2010: 104-108). Independently from these sites, there is also evidence that some millstone makers resorted to independent blacksmiths, whereas others possessed the skills and infrastructure to do the work themselves.

Two quarries in our study are associated with smithy related place names: *Las Fraguas* (the smithies) beside the *Molares* quarry at Montarrón, Guadalajara (GUA-8) and *Las Herrerías* (the smithies), the name of the a still active quarry at Bolaños de Calatrava (CR-2) with evidence of Roman millstone workings.

At Montarrón (GUA-8), a direct relation between the Medieval to Contemporary millstone extractions and the smithy work, is perfectly conceivable since the names *Molares* (or *Morales)*, indicative of millstone work, and *Fragua*, indicative of iron work, appear side by side in the cadastre. However, it is doubtful that the quarry work provided enough work to maintain the smithies active on a permanent basis. Like in the case of Châbles (see below), the smithies probably took part in other activities.

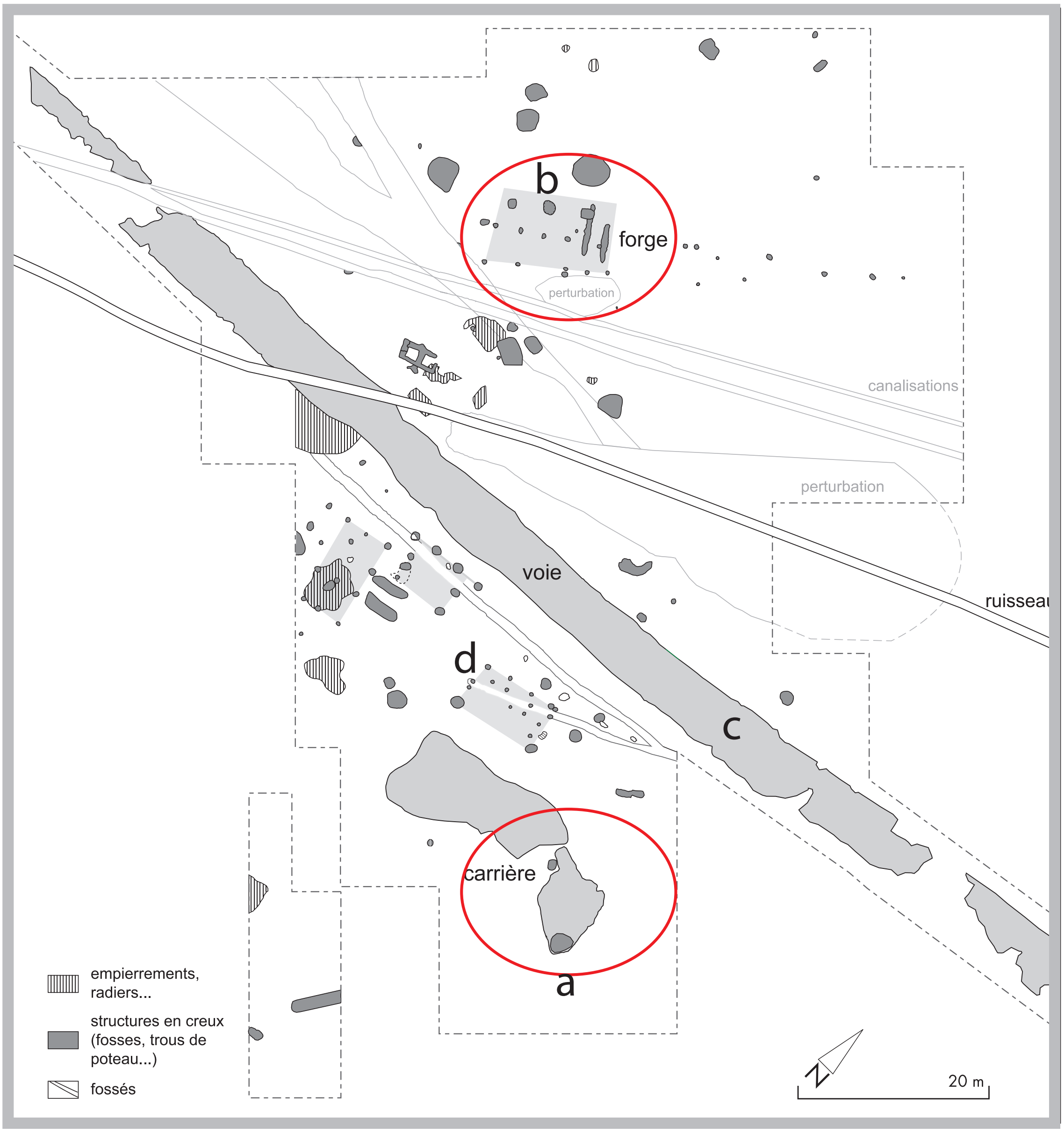


Fig. 8.1: Plan of the Gallo-Roman site of Châbles-Les Saux dating to the 1st-2nd century AD (Canton of Fribourg, Switzerland). The a) millstone quarry and the b) smithy are circled. The study of this excavation revealed a tight link between the smithy and the quarry (adapted from Anderson et al. *2003: 34, fig. 23). The other noteworthy features are the c) road and d) house interpreted as the residence of the quarryman.*

In the case of the presumed smithy of *Las Herrerías* case, a direct relation between the two crafts is unlikely because the *Herrerías* place name probably has its origins in Late Medieval or Modern times, after the Islamic fall, whereas the millstone extractions are Roman. It is more plausible that the hypothetical *Herrerías* smithy was linked to iron working that served a later phase of stone extraction (probably for construction).

The excavation of Châbles-Les Saux in the Canton of Fribourg, Switzerland, brought to light a small Roman quern quarry connected with a nearby smithy (fig. 8.1). A major Roman thoroughfare 6 m wide passed between the two features. The detailed study of this site reveals a direct correlation between stone and iron work (Anderson *et al.* 2003). However, maintenance of the quarry tools, about 80 m from the smithy, did not generate enough work to sustain the smithy. The smithy therefore also serviced a local and regional clientele that gained access to the site by means of the road.

The recent excavation in France at the subterranean millstone quarry at the Grand'Gueule (Mont Vouan), under the direction of A. Belmont, brought to light in a test pit at the rear of the cavern, a large quantity of smithy slag and hammer scales in a black, carbon-rich, layer of sediment. The quarry, dug into the steep slope halfway up the mountain, was accessible only by a narrow winding trail. Radiocarbon dating places the smithy work in the 15th-16th centuries. The remote location of the site, about a half-hour hike uphill from the nearest town, suggests that this smithy operated exclusively for the millstone quarry (Belmont & Anderson 2010: 104-108). This assessment would seem compatible with the constant need of repair and maintenance of the tools of a massive millstone exploitation.

In northern Spain at Barruleo de Santullán (Palencia), a Municipal Ordinance dating to 1571, provides an interesting view of the connection between smithies and millstone quarries. According to chapter 10 of the Ordinance, blacksmiths were obliged, under threat of a heavy fine, to drop all activity at the request of a millstone maker to repair his pick so that he could return as soon as possible to the quarry (Maestro Hernández 2011: 17-18). This record reveals not only the importance bestowed upon and the privileges granted to millstone makers, but also that the smithy was, at least in this case, subordinate to the millstone workers and his smithy was independent of the quarry and probably located in town.

Millstone research in the Palencia mountains by Maestro Hernández also indicates that in the first half of the 20th century, millstone cutters remained stationed at the mountain quarries for up to four days and only descended to town when they needed to repair their tools (Maestro Hernández 2011: 38). Some of them possessed their own smithies (equipped first with traditional bellows and later electric blowers) so as to be self-sufficient (Maestro Hernández 2011: 38, 43).

It would therefore appear that larger millstone production centres benefitted from smithies at the site for tool maintenance. Quarrymen at smaller productions, by contrast, appear to have relied on blacksmiths or acquired smithy skills themselves.

8.2. Debris management

The quantity of working debris and its position in the quarry is directly correlated with the type of quarry. True extractive sites produced more primary extractive debris at the place of extraction and less secondary fashioning debris. Sites where angular blocks were detached with levers, by contrast, produced less primary debris, but more secondary debris where the square block was hewn into a cylinder. When this fashioning took place away from the quarry face, which seems to be the case, then the debris was negligible, and not a hindrance to further extractive work. In true extractive quarries, by contrast, the primary debris had to be removed to be able to pursue extractive work.

Pit, bench, pocket and subterranean quarry debris hindered work and thus required constant removal. Edge, extensive shallow and extensive dispersed quarries required little debris management. Debris never attained a volume large enough to hinder the work progression because it could be left beside the extraction. In the case of coastal sites such as Trafalgar (CA-1), Chipiona (CA-6), Rota (CA-3) and Carchuna (GR-9), over time, debris was washed away by the water as is the case of most of the quarries of Menorca (J. Sánchez pers. comm.).

In certain cases, debris could be put to particular use. As we will see later, debris was used in the backfill of retaining walls serving as ramps to enter and exit the quarry. At the Roman site of Châbles in Switzerland, the larger elements were used to repair the foundation of a nearby road, whereas the finer gravel debris, was used to pave the road (Anderson *et al.* 2003: 181-182).

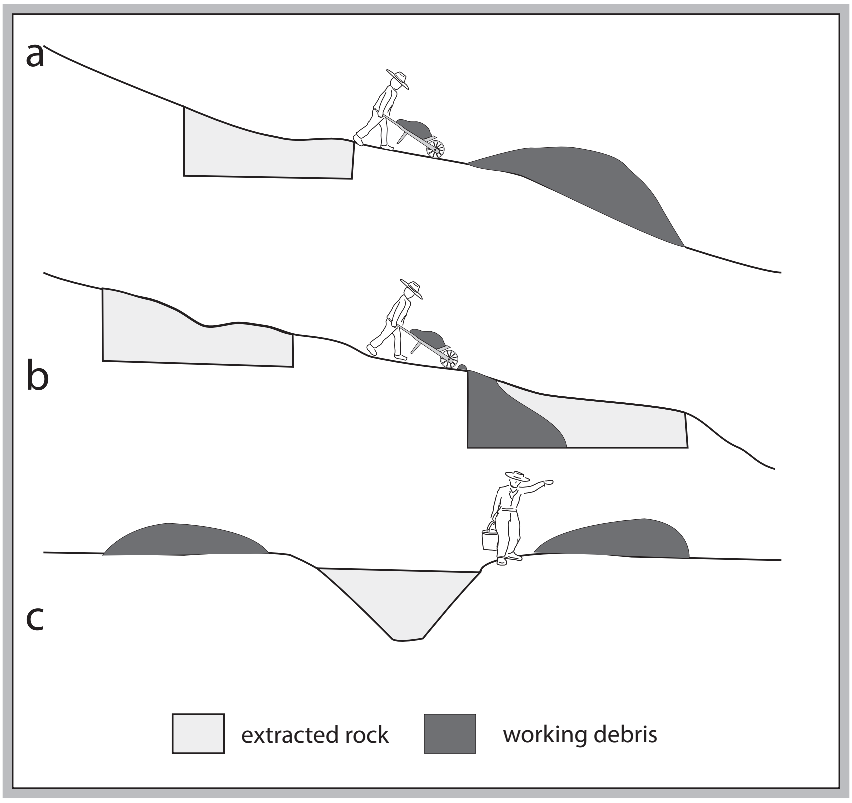


Fig. 8.2. Schematic sections of quarries relative to working debris: a) downslope heap, b) debris backfilled in finished extraction area and c) debris placed in long cordons along the edge of a trench quarry (drawing by T. Anderson).

In other contexts, by contrast, millstone makers had to invest a larger amount of energy and time into managing debris. Certain unusable superficial layers of overburden required removal before initiating proper extractive activity, an activity that generated at times a large amount of debris. The nature of this debris differed from that of extraction or fashioning in that it could include humus and/or organic topsoil giving it a darker colour. It is therefore plausible that in a future (hypothetical) excavation of one of these sites, archaeologists will observe "inverted" stratigraphies, that is, a sequence with the humus and topsoil at the base and rock carving debris at the summit.

Extraction debris could also include large rock fragments mixed with the finer material, resulting from the elimination of unsuitable rock sectors to make way for subsequent work. In the debris there are also at times discarded cylinders. These are "treasures" for the archaeologist, in particular, at sites with many phases of extraction, because they allow a correlation to be made of certain stratigraphical layers with a certain extraction zones.

8.2.1. Downslope debris heaps

The debris of millstone quarries had to be evacuated and stored in sectors devoid of rock apt for subsequent extraction so as to avoid having to be moved a second time. For this reason, spoil heaps were situated beyond the working areas, most often downhill so as to profit from gravity during transport (fig. 8.2).

At Ibi (A-2), Alicante, the modest quantity of debris of quern extraction along the steep slope required little or no management and was presumably no hindrance to subsequent work. It was blown away by the wind and washed downhill by rain. At Moclin (GR-1a), its volume was much larger and had to be carted away and thrown downhill where it can still be seen today (fig. 8.3). The presence of half-fashioned roughouts in that area indicates that this debris originated both from extraction and fashioning.

In the case of the edge quarry of Alhama de Granada (GR-6), the debris, made up of a number of interlocking mounds, formed a wide continuous cordon more than 100 m long (fig. 8.4). This spoil originated from pushing the debris downhill from the adjacent fashioning workshops. The oval and elongated heaps between 10 and 20 m long at the pocket quarry of the Sierra del Hacho near Estepa (SE-3) were probably moved downslope by wheelbarrow (fig. 8.5).

Fig. 8.3: General view and detail of the downslope working debris (extraction and fashioning) beside the deep extractive area of the Moclín quarry (GR-11).

Fig. 8.4: General view of the extended face, block detachment, quarry of Alhama de Granada (GR-6). The fashioning of millstones from angular blocks near the quarry face has produced a large amount of debris that was dumped downslope, resulting in one long cordon of stone debris.

Fig. 8.5: Oval shaped spoil heap downslope from a pocket quarry at the Sierra del Hacho, Estepa (SE-3).

8.2.2. Backfilling finished sectors

A second option for storing working debris was to backfill finished sectors of the quarry (cf. fig. 8.2b). This technique, characteristic of large extractive quarries, was observed recently at the excavations undertaken by A. Belmont at Claix in Charente and Mont Vouan in the Haute-Savoie. In our study area this has only been observed in the larger, more structured, quarry sites of Moclín (GR-1a) and Cantera de los Frailes near Cabra (CO-1).

It must be noted that debris backfilled in finished quarry sectors is an optimal feature to explore in a modern archaeological excavations, because it offers the possibility to analyse, through vertical stratigraphy, the chronological sequence of the backfill. At Claix in Charente, for example, pottery and discarded quern finds in the backfill, allowed to establish a relative chronology between two separate sectors of extraction (Belmont *et al*. 2011: 207). Furthermore, as seen systematically in the excavations in France, backfilled debris protects the quarry floors and quarry faces from weathering, providing the archaeologist with rare opportunities to observe and interpret well-conserved tool marks.

8.2.3. Lateral cordons (trench quarry debris)

Debris from trench quarries (cf. fig. 8.2c) was stored in long parallel cordons placed to each side of the edge of the trench (fig. 8.6), as seen at the sites of Caniles, Cantera de la Rambla (GR-11) and El Lachar near Jimena (J-2) (fig. 8.7). To avoid having to move the debris a second time, subsequent trenches had to be opened a reasonable distance from the original trench, beyond the cordon of debris.

Fig. 8.6: Long cordons of fashioning debris parallel to the trench quarry of the Caniles (GR-11).

Fig. 8.7: Cordons of working debris along the edges of the trench quarry of El Lachar (J-2).

8.2.4. Retaining walls

The site of Lachar, Jimena (J-2), in one of the deeper sectors of a trench, presents two levels of drystone retaining walls backfilled with spoil (fig. 8.8). This type of feature, recorded in the basalt quarries of the Eifel (Harms & Mangartz 2002: 78, 85) at Claix (Charente) in southwestern France (Belmont 2011: 9), is unique, at least for the moment, in southern Spain. As is the case in France, these backfilled walls may also have served as paths for the workmen to enter and exit the trench, as well as a "slipways" to haul the blocks or cylinders out of the trench.

Fig. 8.8. View of retaining walls at the Lachar quarry near Jimena (J-2). The drystone walls not only retained working debris, but also served as paths to enter and exit the trench. They also served as slipways to drag out the blocks or millstones from the base of the trench.

8.3. Residences and shelters

8.3.1. Long-term residences

The aspect of the type of residence or shelter that millstone makers enjoyed while working at the quarry depended on whether the production was a permanent or seasonal activity. It is assumed that workers at sites such as Moclín (GR-1a), adjacent to town, could shuttled back and forth from their houses every day. But there were sites too far from towns that required some means of shelter or lodging.

The only archaeological feature interpreted as a residence of millstone makers is a rectangular timber-framed house brought to light beside the quern quarry at the Roman site of Châbles-Les Saux in Switzerland (Anderson *et al.* 2003: chap. 8) (fig. 8.9). This modest, post construction (45 m2), with roots in the regional Celtic tradition, is similar to the rudimentary Roman huts on contemporary regional agricultural domains (Anderson *et al.* 2003: 218). The question remains unresolved as to whether the craftsmen resided in this hut on a permanent or seasonal basis.

One of the rare glimpses into the question of the lodgings of millstone makers in our study area is from the quarry of Berrueco (Cádiz) (CA-8). The priest of the town of Medina Sidonia wrote that the men that made mills (in the 18th century) at this huge quarry were residents of Medina Sidonia (Martínez y Delgado 1875: 129). He did not make clear, however, if they made the 10 km journey from town, including a long return hike uphill, on a daily basis.

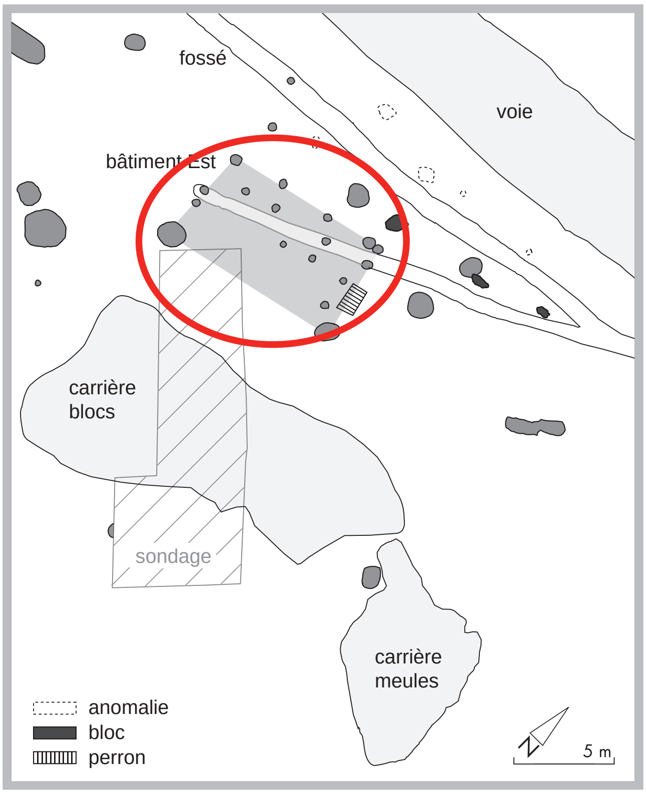


*Fig. 8.9: Plan of part of the Gallo-Roman site of Châbles-Les Saux dating to the 1st-2nd century AD (Canton of Fribourg, Switzerland). The rectangular house (*bâtiment est*), built with wood, was between the road and the quarry (*carrière*). This modest structure is interpreted as the residence of the quarryman (adapted from Anderson* et al. *2003: 196, fig. 241).*

A second author, Cruz y Bahamonde, in the first decades of the 19th century, provided even more insight into residence El Berrueco. He records that "... on top of the Berrueco mountain there are several buildings that house about 50 millstone makers" (Cruz y Bahamonde 1813: 91, note 1). With this number of workers it is obvious that production was at its height. Although there is no evidence, it is conceivable that the site also had a canteen to feed the workers.

Madoz, 30 years later, notes that 24 men resided at the site and worked in five different workshops (Madoz 1846, Vol. 4: 290). The extensive recent extractive work (for construction) has probably obliterated all the traces of the early lodgings. In any case, it is evident that the workers of large millstone production centres at times were housed, indicating they remained at the quarry at least on a seasonal basis.

8.3.2. Short-term shelters

Millstone makers also built simple huts or hovels as shelters for the short periods of time passed at the site. Crude drystone shelters are present at or around sites of El Lachar (J-2), El Torcal (MA-1) and (J-2) Ubrique (CA-12). At Lachar several of these features, called *caracoles* (meaning snail shells) are erected against the edge of the quarry trench and surrounded by abandoned millstones indicating they coexisted contemporaneously (fig. 8.10). These huts are very small and appear to have served for little more than a shelter to pass the night or take a rest from the hot sun. Although they are dark, with no windows, and ideal for smithy work, they show no evidence (slag) of iron working.

At the Peña Harpada (CA-10) the quarry shared the summit of a pointed mountain with what are interpreted as Medieval defensive constructions (Giles *et al*. 2011: 128-130). These earlier features could have later served as a refuge for the millstone makers. The dwellings at El Torcal (MA-1) are more complex (fig. 8.11). Beside a very crude shelter with a very small door and a number of broken and unfinished millstones in the surroundings, there is a drystone enclosure (about 100 m2) suggesting the presence of animals. Hence the shelter may be simply related to pastoral activity and had nothing to do with the quarry. A second interpretation is that the quarrymen resided at the site periodically in the company of their animals, possibly including oxen used to transport the millstones.

*Fig. 8.10: Views of two different drystone dwellings at the trench quarry of El Lachar (JA-2). In the local vernacular, they are called "*caracolas*", meaning the snail shells.*

Fig. 8.11: View of a dwelling at the quarry site of El Torcal (MA-1). The feature, strewn with finished and unfinished millstones, comprises a crude drystone hovel and a drystone enclosure: a) general view; b) detail of the hovel; c-d) views of the enclosure wall.

8.4. Transporting millstones

8.4.1. Generalities

Querns and millstones were transported by different means depending on their weight, type of terrain and the distance to their final destination. For both short- and long-distance transport, the proximity of a road was essential to the life of a quarry. The quern exploitation of Châbles in Switzerland, for example, owed its existence to the major public road that preceded it (Anderson *et al*. 2003: 185). The millstone outcrop of Villanueva de San Juan in Seville (SE- 6) illustrates the importance of a preexisting route. In the words of Madoz, the site "...was not exploited for lack of a road" (Madoz 1850, Vol. 16: 207).

Small handquerns, weighing less than 50 kg, could be lifted by one or two workers and placed in the bed of a cart. Lifting larger models, weighing up to a tonne, was another story. These massive cylinders had to be guided and slid by levers along wooden tracks or slipways out of the extractive area to be loaded into waiting carts. At certain more sophisticated sites, they were hoisted out of the quarry by cranes or capstans, features still visible at the volcanic quarries of Mayen in Germany (Harms & Mangartz 2002: 88-93) and at Selbu in central Norway (Grenne *et al.* 2008: 61, fig. 25). In our study area, however, there is no evidence of these types of installations.

In southern Spain, most sites were near major or secondary thoroughfares linking different centres of population. These roads were often *camino reales*, maintained by the authorities, often borrowing trade routes dating from Antiquity or routes used for seasonal migration of livestock.

Some smaller roads leading to millstone exploitations have left their stamp on the toponyms. As we have noted in a previous chapter, the site of the Albardado, for example, is accessed from the town of Belmez by a road called the *Camino de la Pedrera* (CO-10) (road of the quarry).

The possibility of damage to the millstone during transport was a constant worry for the mill maker and the client. A story is told that a miller in northern Spain offered the local church a property in exchange for divine protection during its transport. Apparently the millstone arrived in perfect condition because the property now is in possession of the diocese (Pascual *et al.* 2011: 248). This was not, however, always the case. An accident to the millstone could explain the abandoned examples along the roads to the quarries of Alhama de Granada (GR-6) and Vélez de Benaudalla (GR-10) (fig. 8.12).

a

Fig. 8.12: Examples of millstones abandoned along access roads to the quarries of a) Fuente de los Morales, near Alhama de Granada (GR-6), and b) Barranco de las Piedras, near Vélez de Benaudalla (GR-10). The reason for the abandonment is not certain. It is possible that they broke during transport.

8.4.2. Short-distance transport

For land transport, the most usual means was the dray or cart with a flat bed and spoked wheels, probably similar to the carts for transporting building blocks illustrated in the 16th century by (pseudo) Juanele Turiano (fig. 8.13). It appears from a photograph of an early 20th-century block quarry cart from Extremadura that it did not change much over time (fig. 8.14).

In the Palencia mountains as late as the 1960s, it is recorded that millstone transportation carts, well adapted to the rugged terrain, were equipped with massive wooden wheels and wooden axes (Maestro Hernández 2010: 45). The author further relates that in inclined terrain, to facilitate loading the stone onto the bed of the cart, the cart was positioned downhill and, so as to lower its bed, the wheels were placed in holes dug in the ground (Maestro Hernández 2010: 45).

In old Spanish illustrations and photographs of quarry carts, we note that although mules are at times represented, most were drawn by oxen. In the 1502 Loja (Granada) Municipal Ordinance (see GR-2), for example, the penalty for removing millstones without the consent of the authorities was the confiscation of the oxen used to draw the millstones. In the more recent productions in the Palencia mountains, the millstone cutters, who also raised livestock, often

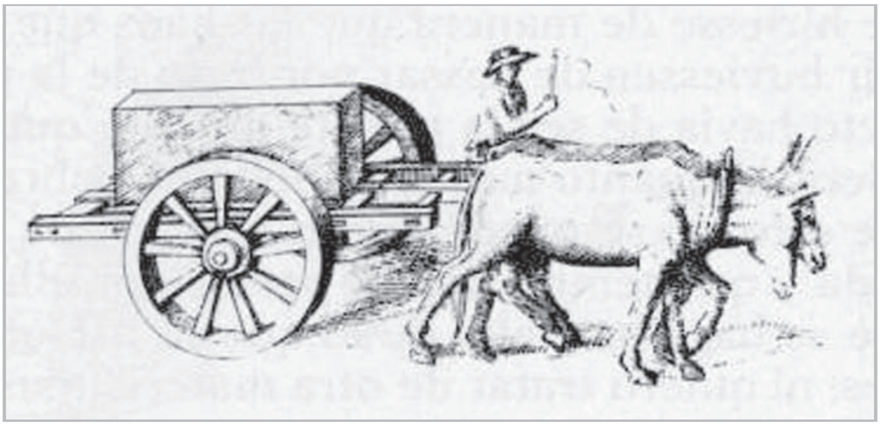


Fig. 8.13: Drawing from the pseudo Juanelo Turriano codex (c.1595) of a quarry cart driven by mules (from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).

Fig. 8.14: Modern flatbed quarry cart from Extremadura (from Martín Galindo 2006: 849).

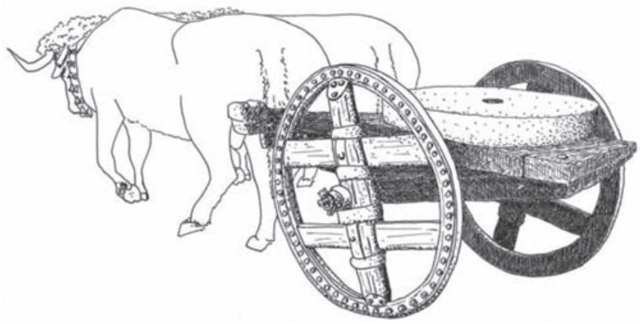


Fig. 8.15: Reconstruction of an oxen-drawn cart for the transport of millstones and other heavy production, based on information from the region of Navarra (from Pascual et al. 2011: 250, fig. 25, drawing by J. Castro).

used their own oxen to both drag the millstones down the mountain, as well as to pull carts (Maestro Hernández 2011: 46). An oxen-drawn millstone cart from northern Spain has been recently reconstructed in an illustration by J. Castro (fig. 8.15).

A second means of transport was the "Y" shaped sledge called *corzas* or *basna* made of oak. These were also used to drag millstones along flatter lands. The millstone was attached with chains on the "V" part of the sledge and harnessed to oxen by means of a second chain attached to the base of the "Y" (Maestro Hernández 2010: 48).

This type of sledge is known elsewhere in Spain in a more simple "V" shape called *rastra* (from the word meaning to "drag") (fig. 8.16). The piercing of the eye of the millstone, seen very often at Spanish quarry sites, probably facilitated attaching the mill to the sledge.

Millstones could be hauled from their point of extraction and fashioning by other means. One simple method identified in the Palencia mountains, especially in difficult terrain, was to "wrap" them with long branches of broom, a shrub abundant in the area, and haul them along the surface behind oxen until attaining the point that could be reached by a cart Maestro Hernández 2011: 46).

Fig. 8.16: Examples of recent "V" shaped rastra *sledges designed to transport heavy loads (photograph A from http://cuentoquenoescuento.blogspot.com.es/2012_02_01_archive.html; photograph B from http://espanolinternacional.blogspot.com.es/2008/03/el-transporte.html).*

Another means of transporting millstones described by Maestro Hernández (2011: 47), based on the research of Francisco Javier González in Brañosera, was to stake their location with a long poles and wait until the arrival of snow so as to slide them to town on crude snow sledges. This transport, recalling that of the quarries of Selbu in Norway (Grenne *et a*l. 2008), was certainly not known in the milder climate of southern Spain.

According to a recent quarry study in the northern autonomy of Navarra, transport of millstones in difficult terrain was carried out with *narrias*, a type of simple sledge towed by oxen with parallel blades, united by a platform of crossbeams (fig. 8.17) (Pascual *et al.* 2011: 249, fig. 23). The authors cite a notarial archive relating that in 1419, María Ruiz de Arregui sold some properties to a monastery but retained the rights for herself and her successors to not only extract millstones, but to cut the wood necessary to transport the millstones. Two centuries later, in 1634, a document records that no wood could be cut unless needed for the transport of millstones (Pascual Mayoral *et al.* 2011: 249). Both of these documents imply, presumably, that the sledges to transport the millstones were either improvised at the extraction site or there was a need of wood for the rails on which the sledges were slid.

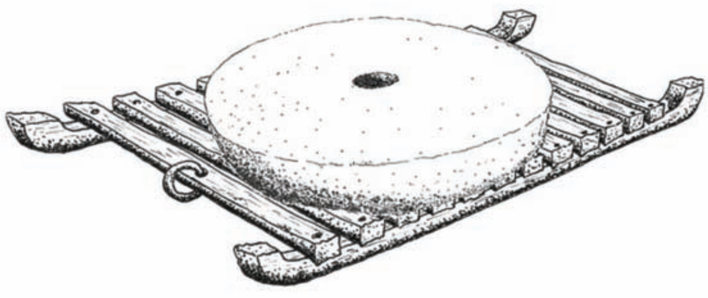


Fig. 8.17: Example of a narria *(from Pascual Mayoral et al. 2011: 249, fig. 23; drawing by Javier Castro).*

In our study area, there are five independent accounts that describe yet another singular means of moving millstones. This system could be labelled the "rolling stone" technique. It consisted of placing the millstone upright, slipping a beam through its eye like an axle and, while two men stabilized the axle, a third pushed it. This technique, obviously not applicable in highly inclined terrain, was described to us orally by "Niño" Ernesto, a resident of Moclín (GR-1a), Granada. It is also documented in studies of watermills of the Alpujarras of Almería and Granada (Cara Barrionuevo *et al.* 1999: 151; Rodríguez Monteoliva 1989: 705-706). Another identical anecdote appears on the internet related to the quarry at El Esparragal (CA-12), outside the town of Ubrique (Cádiz) (http://manuelcabelloyesperanzaizquierdo.blogspot.com.es/2010/10/como-se-puede-trasladar-una-piedra-de.html). A variant of this method is described and illustrated by Gómez Ruíz (2003: 85, fig. 7) in his study of watermills along the Odiel River of Huelva. In this last case, instead of being pushed by a man, the millstone was pulled by a mule (fig. 8.18). This crude and seemingly risky technique was certainly limited to short distances, for example from where a cart was not available (Rodríguez Monteoliva 1989: 705-706).

Fig. 8.18: *Reconstruction of a scene of moving a millstone by means of the "rolling stone" technique (from Gómez Ruíz 2003: 85, fig. 7).*

Another feature recorded in association with millstone quarries is that of rutted roads cut directly into bedrock. These grooves were used to guide loaded carts or sledges. An example is at the vast millstone exploitation of Claix near Angoulême (Charente) (Belmont *et al.* 2011: 219-220, fig. 24). In northeastern Spain, a Roman or Medieval rutted road, identified over a distance of 2 kilometres, is directly related to a quarry (exploiting cylinders, possibly millstones, measuring 60 to 80 cm in diameter) at Cerro Redondo, Zaragoza (Cisneros 1983: 158-159, figs. 13-14). In our study area, there are no rutted roads that can be associated irrefutably with millstone production. One track, nonetheless, passes very near the the northern entrance of the mountain pass beside the quarry of Puerto de la Cadena (MU-1) that would have helped stabilise the heavy loads of millstone transport (fig. 8.19).

Fig. 8.19: Example of a rutted road cut through a conglomerate embankment. This road is near the quern and millstone quarry of the Puerto de la Cadena (MU-1). A possible relation between the quarry and the road is not certified. (from http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/).

8.4.3. Long-distance transport

8.4.3.1. Inland cart transport

Cart transport was the most common means of long-distance transport owing to that most millstone production in Spain was undertaken and destined to inland markets. In Antiquity and Medieval times, the inland transport of querns and millstones certainly benefitted from the network of established trade routes. Unquestionably, there were periods when the roads were in better or worse conditions. The presence of volcanic querns and millstones far from volcanic sources, are definite indicators of long-distance inland trade. Physical evidence of carts with quern and millstone cargoes have never, however, been documented in our study area.

Some old written sources relate the overland transport of millstones. An example is the tale of Santiago García in 1766, who ferried a millstone about 70 km from Trébago in the Sierra del Madero (Soría) to the town of Mendavia in the south of Navarra. He was obliged to pass the mountain passes of the Iberian System range (up to 1000 m in height) before crossing the wide Ebro River to collect a sum of 704 *reales*, a large sum at the time (Pascual & García 2011: 291-292).

At times, transport was undertaken by the customer who retrieved the millstone himself, either with his own or a hired vehicle. At other times, it was the millstone maker himself who transported the stone. The son of Herminio Miguel, the central character of photograph of the *moleros* of Brañosera (cf. chap. 1, fig. 1.6), recalls that his father conveyed stones to Oña in the province of Burgos, about 80 km to the SSE, and to Puente Almuhey in the province of León, about 60 km to the west. Sauro Miguel, the man to the right of the photograph, transported one to Villarmoronta near Carrión de los Condes, about 60 km to the south (Maestro Hernández 2011: 47). Although these may not appear to be long distances "as the crow flies", they were rough trips through mountainous terrain that took several days.

Part of millstone transport was also carried out by a long-established network of professional *arrieros* or *carreteros*, transportation "guilds" that ferried products throughout the Spanish countryside by animal (mostly mule) or cart (Espejo Lara 1983; Diago Hernando 2004: 219). It is interesting to note that there is a protocol in the Provincial Archives of Seville detailing the sale of a millstone in 1510, from the *carretero* Juan Gallego of Catedral to Alonso dé Castañeda of Huévar (Otte 1996: 58, note 24). The *carretero*, in this case, seems to have taken on the role of a millstone merchant.

Pascual Mayoral and her team recorded that they interviewed the *arriero* Amador Gastón from Mués (Navarra), who in former times hauled millstones from the quarries on *narrias* drawn by four oxen (2011: 236).

A series of documents identified by Mª I. Sainz (2007: 176-178) in the archives of Mendieva, Navarra, indicate the distance and, on occasions, the time of transport from different quarries to Mendieva. The first, dating to 1713, described the costs of acquisition and transport of a lower stone which included paying the Mayor and the toll of the town of Arubal (La Rioja), the ferryman for the crossing of the Ebro River and wine for the people that fetched the stone. A document from 1789, notes that Antonio Elvira was paid to drive a lower stone from Arbeiza, a distance of about 30 km. In 1800, Benito Balerio was paid to bring a stone from Logroño (La Rioja), a two-day trip for the approximately 25 km. In 1801, Fausto Durana and Isidro Robres were paid for a stone brought from Treviño (Burgos), about 50 km away. In 1804, Santos Elvira and Benito Balerio took three days with three sets of *caballerías* (probably mules), and two different carts to convey a millstone from beyond Logrono (La Rioja), a distance of at least 30 km. Finally, in 1805, 211 *reales* were paid to deliver a stone from Logroño (La Rioja) about 30 km away (Sainz 2007: 176-178).

These archives do not relate in detail the "on the road" obstacles and dangers these men had to overcome to deliver the millstones.

8.4.3.2. Fluvial and maritime transport

In Antiquity, transport of querns and millstones by water was advantageous for both the millstone exporter and the ship. Water transport gave the millstone merchant the option of wider, more distant markets, while, at the same time, affording ballast for the ship. Roman querns made in the Cabo de Gata volcanic district (see AL-1; AL-2), for example, were in a short walking distance from waiting ships in the deep-water coves along the Mediterranean coastline.

No cargo of Roman rotary querns has been published along either the Atlantic or the Mediterranean coastline of southern Spain. In Catalonia, however, a wreck has been identified at Illa Pedrosa, off the coast of Girona, and excavated for the first time in the 1960s. Its cargo comprised 130 rotary (60 *catilli* and 70 *metae*) originating, according to analyses, from a quarry near the settlement of Ullastret (Girona) (Vivar 2004: 101-104). This assemblage, unfortunately never thoroughly published, is the best example of maritime transport of Roman millstones originating in quarries of the Iberian peninsula.

As to Roman fluvial transport, it is established that the Guadalquivir and Guadiana Rivers were navigable from the Atlantic coast into the heart of *Hispania Baetica*. Millstones from the quarries in the volcanic district of Campo de Calatrava could have been gathered at a staging point at the city of *Corduba*, as were other mineral resources, for river transport down the Guadalquivir. The Guadiana, likewise, was navigable from at least Mérida (*Colonia Iulia Augusta Emerita*) to the Atlantic coast. Once again, there is no evidence that stones travelled these river routes. No millstone cargo has been discovery such as that a 3rd century AD cargo of volcanic millstones at Wanzenau (Alsace) in an ancient bend of the Rhine (Forrer 1911).

In more recent times, maritime trade of the Montjuïc stone from Barcelona is known to have continued into the 18th century with stones reaching as far as the Provence in France, Murcia in southern Spain, and possibly Genoa in Italy (Español 2009: 967).

In our study area, there are historical archives that point to the millstone transport in 1508 along the Mediterranean coast of Málaga. Four stones, probably from El Torcal (MA-1), were ferried by Francisco Martín from the Cala del Moral to Torre de Vélez (Fernández López 1982: 221, note 10).

Finally, maritime trade is indicated by P. Arjona (citing Ponce 1981) that two 19th-century Portuguese ships ("*Felicidade*" and "*O que Deus Quera*") sailed from their home ports to acquire shell-rich (conglomerate) millstones from Rota (Cádiz).

8.4.3.3. Rail transport

The rail network was only introduced in the south of the Iberian Peninsula during the second half of the 19th century. Millstone production at certain larger Spanish quarries most likely took advantage of this new means of distribution. The railway branch of several kilometres to Gerena, Seville (see SE-7), connecting it with the Azmallcóllar -Guadalquivir line, was built specifically to serve Gerena's granite quarries (Perejil Derey 2005). Transport by rail of granite building blocks from these quarries is documented by old photographs (fig. 8.20). Oil rollers, produced in the district (and possibly millstones), also benefitted from this staging area for regional distribution (Perejil Derey 2005). Although there is no evidence, millstone workings in the granite fields must have also taken advantage of the rail.

Fig. 8.20: Scene at the loading platform of the train station of Gerena (Seville), where granite blocks were loaded onto wagons. Oil rollers and millstones probably also benefitted from this means of transport (photograph from http://lafactoria-cuencaminera.blogspot.com.es/2010_12_01_archive.html).

The growth of the train network opened new markets for some quarries in southern Spain. The group of millstones in a photograph (fig. 8.21) at the loading platform of the station of Huelva are most likely, due to the absence of iron bands around their girth, from regional quarries and not French imports. It is tempting to imagine that they arrived in Huelva to equip a local mills or to be transported elsewhere by boat.

In any case, while the rail was beneficial to some larger Spanish regional quarries of the mid-19th century, it ultimately played a crucial role in their demise, since it accelerated the arrival of silicious millstones from France, the famous composite *meulas francesas* bounded with iron bands.

Fig. 8.21: Huelva train station towards the end of the 19th century with 5 millstones in transit. Behind the upright example (to the left), are three others. The stone to the right, under the sitting official, appears to have a fracture along its lower rim. The absence of iron girth bands reduces the likelihood that they were composite French Burr imports. The Huelva-Zafra rail line was built between 1867 and 1900. The station is by the port, as seen by the boats in the background to the right (photograph from http://lafactoria-cuencaminera.blogspot.com.es/2011/06/casas-espanolas-al-borde-de-un.html).

9. THE MEN BEHIND THE MILLSTONES

There is very little data about the people who worked in millstone quarries, that is, their level of expertise, the organisation of working crews, their wages, whether they exercised other professions and the impact of their work on their health. Some of the following considerations on these intangible aspects of millstone production derive from old written documents and archaeological excavations outside our study area. We also borrow heavily from writings about the quarries of Montjuïc by Barcelona and the white marble quarry of Macael in Almería. The Montjuïc was the both a producer of millstones and building blocks, whereas Macael was a rival to the marbles of Carrara, Italy. Our knowledge of the people that exercised the mill making profession, nonetheless, remains restricted to a number of short, fragmented vignettes.

9.1 The millstone makers

Professional millstone makers, like all stone cutters, were robust, brawny individuals. Through the physical toil and the difficult working conditions, they developed taut muscular frames and a tough mind-set. The crews at the Berrueco quarry (CA-8), according to Madoz, reserved the right to bear arms (explosives in this case) not only to level crags at the Berrueco and the town of Medina Sidonia, but because they also chased down *rateros* (thieves) that occasionally turned up in the area (Madoz 1848, Vol. 11: 343).

We know only a few millstone makers by name. Juan de Bargas, for example, was an early 17th-century stone mason who scored millstones at the Albardado quarry (CO-10) near Belmez, Córdoba (Gonzáles Perralbo 2008). The exceptional acquaintance with the names (and even nicknames) of the two sets of fathers and sons comprising the Brañosera crew from the mountains of Palencia, photographed in 1933 (fig. 9.), is by virtue of the interviews conducted by Maestro Hernández with their descendants.

The photograph is also evidence that the millstone trade, like many professions of the past, were imparted from father to son. Furthermore, the Maestro Hernández interviews indicate that millstone making was a complementary trade to their principal occupation as farmers (Maestro Hernández 2011: 48).

Fig. 9.1: Photograph dating to 1933 of moleros *(millstone makers) at the quarry of Brañosera (Palencia) in northern Spain. Some are identified by name in the study of Maestro Hernández (2011: 40): to the left are father and son Manolo and Antonio García; in the background only one of the men, Gerardo, is identified. Herminio Miguel is in foreground and to the right is his son Sauro (photograph from Cuevas Ruiz 2006).*

9.2. Permanent or seasonal work

Although millstone-making required a profound, intuitive knowledge of the rock and its properties, skills to handle specific tools, and techniques developed through years of experience, millstone making was not necessarily a full-time, year-long profession. We suspect that most quern and millstone quarries serving local and regional needs were only in operation when the climate permitted and when purchasing orders were received. A few larger production centres, serving a larger clientele and benefitting from a constant influx of purchasing orders, were manned on a permanent basis.

In southern Spain during Late Prehistory and part of Protohistory, the evidence suggests that most querns originated in the form of loose surface blocks. There is little evidence of veritable bedrock quarries. The Prehistoric settlements of Los Pensadores and Las Rajas (Pinos Puente, Granada), for example, were a short walk from the presumed bedrock quarry of Zujaira (GR-12) (Anderson 2010). Since these grinding implements were not necessarily fragile, and did not need be constantly replaced, it seems evident that quern-making in these early societies was an occasional occupation carried out parallel to other domestic tasks.

For the Iron Age the existence of monumental architecture and statuary in the Iberian Culture suggests a high degree of rock-carving specialisation. Some of these stone workers could also have extracted and fashioned rotary querns and millstones. This does not exclude that they, like their earlier counterparts, spent most of their time tending to their fields and flocks.

In Roman times, with a massive production of volcanic rocks at sites such as Cerro de Limones (AL-1) and (Hoya del Paraíso (AL-2), we can imagine craftsmen working exclusively (or at least for extended periods of the year) at quern production. We could go so far as to imagine a separation of tasks at the quarry: specialists extracting the blocks; others knapping cylinders into rough shape; and others fashioning the blanks. This does not exclude that they periodically took part in other activities, depending on the regional climate.

For the Middle Ages in the south, under Islamic rule, we have no data concerning stone cutters. Outside of the sphere of Islamic rule, it is conceivable that the quarry of Montjuïc by Barcelona, owing to its excellent sandstone, as well as its potential for export by sea, provided year-round work for a number of stone cutters who could have divided their time between scoring millstones, oil rollers or building stones. Montjuïc is the only documented production centre in which the quarrymen were united in an official *gremio* (guild) established in the 13th century by the royal authorities (Capmany 1776: 256).

In the notarial archives of Pozoblanco, Córdoba, indicate that Juan de Bargas was both a millstone maker and a stone mason. From the list of possessions drawn up at his second wedding, it can be inferred that he was a specialist of the stone trade and did not participate in activities unrelated to rock work http://depgeografiaehistoria.blogspot.com/2008/02/virgen-de-luna.html.

From the research of Maestro Hernández (2011: 43-44), we can gather that the millstone makers of Palencia , when receiving an order, worked at the quarries in stages of four to seven days, when the climate permitted and depending on their duties raising animals and crops.

Related to the question of permanent or seasonal work is the notion of itinerancy. In Medieval times stonemasons were known to be mobile, travelling from quarry to quarry or construction site to construction site. They were even granted special exemptions from taxes imposed on local populations (Martínez Prado 1998: 11). This model, however, is less applicable to millstone workers because their main activity, contrary to construction worker (often with long soujourns at the buiding site), took place at the quarry and not at the mill, the millstone's destination at the mill. It was therefore the millstone, and not its maker, that travelled.

9.3. Master millstone makers and work crews

As we have previously noted, the size of the crew depended in part on the product and the volume of production. At the small Roman quern quarry of Châbles in Switzerland, due to the limited workspace and the identical tool marks, there was probably only one person scoring cylinders (Anderson *et al*. 2003: 59).He could, nonetheless, have been assisted in other task such as the removal of debris. Châbles was obviously far less productive than the Roman volcanic quern quarry of Cerro de Limones (AL-1), which could have engaged a large number of workers, from to the many abandoned roughouts and the vast amount of working debris visible at the site. Among these workers there was certainly a wide range of levels of expertise and the need for some individuals, the masters, to assert authority over others in order to maintain a rhythm and standard of work.

Fig. 9.2: Photographs of the working crews of the pit quarries of Montjuïc (Barcelona) and Gerena, Seville (SE-7). (photograph of Montjuïc from http://amf2010blog.blogspot.com.es/2012/03/gaudi-y-la-piedra-un-mag-ico-acuerdo.html); photograph of Gerena from Acuña Carabantes 2004).

In the Middle Ages, if millstone workings were like that of construction sites, each quarry presumably had a "master", assistants and apprentices (Martínez Prades 1998: 10). These positions could have been filled by family members. It would be the master, however, who retained contact with the client and, if he did not take part in the work directly, supervised the different activities.

For the quarry of Berrueco (CA-8) in Cádiz we have specific data spanning the first half of the 19th century concerning the total number workers. The traveller Cruz y Bahamonde (1813: 91, note 1) recorded that the site comprised 50 workers. Madoz, 45 years later, records 23 men at the site, split up in five different workshops (Madoz 1848, Vol. 11: 343). This number would, theoretically, correspond to crews of about five men per workshop. Although Madoz and other authors provide no information of how the crews were organised, it is difficult to conceive them not divided by hierarchy, or at least based on longevity and experience.

In any case, master millstone makers and master stone masons shared access to the affluent classes. The stone mason' s contact with the noble class and the clergy occurred during construction of castles and churches. The millstone maker master's contact was less direct, either through with the owner of a watermill, often the nobility or clergy (or a wealthy person leasing the mill) to replace a broken or worn out stone or with the owner or authority of the millstone quarry. These different associations with the affluent class probably raised social standing the master millstone maker.

The Palencia millstone makers in the photograph worked as a team, according to interviews conducted by Maestro Hernández (2011). In the photographs of millstone works at Montjuïc (Barcelona) and the conical oil rollers of Gerena (SE-7) (fig. 9.2), the crews comprise between 10 and 15 men. It is not possible to know if these numbers are representative of the reality of millstone working crews, but they do line up approximately with those of the quarry of Berruecos.

There is no written evidence in our research of the participation of women or children in millstone making. It would, however, not be surprising that some family members assisted the stonemasons, taking on auxiliary roles such as removing debris. This might explain the presence of what appears to be a boy in the background of the photograph of Gerena (fig. 9.3). Through the recent history of Spain, as other countries, children were employed in certain manual professions, at times under appalling working conditions. The first Spanish law prohibiting children under the

Fig. 9.3: Scene of workers from the 1920s from a granite quarry (building blocks or paving stones) in the area of Gerena, Seville, an district known to have produced millstones. The worker to the left could be extracting a stone or metal shard from the eye of the other worker. In the background, to the left, is what appears to be a child (from Acuña Carabantes 2004).

age of 10 years to work in industry, workshops, metallurgy and mines, although passed in 1873, was never enforced (Tiana Ferrer 1997: 47-48). It would therefore not be surprising that children were present at millstone quarries from an early age.

9.4. Earnings

We can speculate that at least since the late Middle Ages, quern or millstone makers were neither impoverished nor prosperous. A notarial protocol dating to 1619 establishing the possessing of Juan de Bargas and his future second wife records that his "riches" were a certain sum of money (not much by the standards of the time, according to González Peralbo, 2008) and his stone working tools. From this we can interpret that his "wealth" resided in his skills and equipment, and not his possession of land.

In the *Survey of the Marqués de Ensenada* (1750-1754), among the professions of the residents of Abengibre (Albacete), was a *picapedrero de molinos* (millstone maker). His daily wages were 6 *reales*, broken down into 4 for work and 2 for expenses. The table of wages of other professions in the same village indicates that the earnings of millstone makers surpassed that of all the other workers of manual trades (wool workers, weavers, tailors, blacksmiths and brick makers) except for that of workers in construction (table 9.1).

Several other old texts suggest the profitable nature of millstone making. The situation of Alconera, Extremadura, cited previously in the *Royal Survey* of 1791, suggests that workers earned more in the millstone or brick/tile "factories" than in agriculture. The Berrueco (Càdiz)

Table 9.1: Table of the daily wages of different profession compared to that of the millstone maker based on the responses of Abengibre (Albacete, Castilla La Mancha) to the Census of the Marqués de Ensenada (1750-54).

Profession	Daily wage	Expenses	Total
Millstone maker	***4 reales***	***2 reales***	***6 reales***
Weaver	-	-	*4 reales*
Wool workers	-	-	*5 reales*
Tailor	*2 reales*	*2 reales*	*4 reales*
Tailor apprentice	-	-	*1 real*
Construction worker	*6 reales*	*2 reales*	*8 reales*
Blacksmith	-	-	*4 reales*
Brickmaker	*2 reales*	*2 reales*	*4 reales*

(CA-8) millstone quarry in the late 18th century, according to the description of the local priest, afforded an "advantageous" daily wage to the workers (Martínez y Delgado 1875: 129). Finally, in the Palencia mountains in the 1950s, making a millstone could mean a sum of up to 300 *pesetas* (per millstone) for the *molero,* above what was earned from the crops and livestock. If the example of Palencia is typical of *moleros* elsewhere, their earnings were a simple supplement to what they made from agriculture, allowing millstone makers to live comfortably but modestly (Maestro Hernández 2011: 48).

9.5. Occupational hazards

Stone workers, as seen in various old photographs, were robust individuals. Through their profession they developed physical strength and endurance, and could withstand long working hours. Their profession, nevertheless, entailed both short and long-term dangers.

The limbs and extremities of millstone makers were always at risk, whether while moving a stone or while pounding the head of a chisel. Some risks, common to most stone workers, are cited in interviews with former workers from the white marble quarries of Macael located in the north of the Province of Almería (González Alcantalud 1997: 117-118). It was the hands, eyes and back that risked the most. Back-related problems were also always present due to adopting unnatural bent and arched working positions while cutting the trenches and lifting heavy materials.

Through years of work in both heat and cold, the skin of the hands became hard, and callouses developed that remained for life. The bright white colour of the rock, reflecting the rays of the sun, provoked burns in the eyes. In millstone working contexts this eye problem was certainly magnified in the many “white” limestone exploitations spread throughout the Spanish landscape. The interviews do not mention, although it was certainly a problem, the threat to the eyes of an impact of an iron or rock shard. In the siliceous millstone quarries in France, millstone makers at times assembled crude protective eye wear out of iron wire and recycled glass (Jagaillous 2002: 158). It would not be surprising that the scene of the two *moleros* in the photograph of the Gerena (cf. fig. 9.3) is that of a worker removing a foreign object from the eye of the other.

It is noteworthy that dust generated by working the Macael marble was not a danger to the lungs of the workers. Most *moleros*, like quarrymen and miners working silica-rich rocks (conglomerates, sandstone, granites, limestones), lived under the threat of the silent, long-term killer: silicosis, a lung fibrosis provoked by the inhalation of silica dust.

There are a number of documented cases of this ailment among the silicious French burr millstone makers in France, where the health of a man could be broken within a period of 15 years (Hockensmith 2009: 207-209). A treatise by the Bonneff brothers dating to 1908 (Agapain 2002: 144-150) and an article by Doctor S. Jagailloux (Agapain 2002: 151-164), detail the horrors of this ailment. A. Belmont has dedicated several pages to the hazard in his study of the French burr quarries (Belmont 2006, Vol. 2: 194196).

These risks, although probably lower in the millstone quarries of Spain, were certainly present. It is noted that workers from Macael, in the difficult years after the Civil War, feared the idea of having to immigrate and work at Franco’s Mausoleum at the *Valle de los Caídos* outside of Madrid, or at the quarry of Montjuïc at Barcelona. In the case of the *Valle de los Caídos*, they feared the idea of working underground, and at the Montjuïc, they dreaded the “lung disease” (González Alcantalud 1997: 110). In Moralzarzal, a town in the Sierra de Guadarrama granite district (about 15 km from the millstone quarries of Colmenar Viejo, M-3), a monument has recently been erected to honour the legacy of the local quarrymen. Most of these men did not perish from accidents, but from silicosis (http://www.conocermoralzarzal.es/canteria.htm).

In spite of the different risks, the administrators of the quarries, if we can trust the example of the Macael, showed little concern for the workers’ safety. The company only provided *botiquines*, either in the form of first-aid kits or rudimentary first-aid posts and stretchers, after a strike by workers in 1922 (González Alcantalud 1997: 117-118). This lack of concern for the safety of on behalf of the owners or administrators of the quarries is probably also applicable to the millstone production.

10. MILLSTONE QUARRY OWNERSHIP AND CONTROL

The following notions regarding ownership and control of millstone quarries in the Late Medieval through Contemporary periods are based on historical written sources. For the earlier periods we are obliged to speculate based, in part, on the archaeological record. In general, and through time, we assume that modest quern and millstone exploitations for local consumption probably went unnoticed or disregarded by the ruling bodies. In turn, larger working, like other potential sources of wealth (such as mines), were coveted and controlled by various interest groups.

10.1. Prehistory to the Iron Age

In our study area, owing to the wide variety of millstone rocks (granites, mica schists, sandstones, limestones, travertines, conglomerates, dacites, rhyolites, etc.) and on due to their availability as surface material, we find it hard to conceive any type of control from Prehistory to the Iron Age over riverbeds, screes and taluses where they were routinely collected. The safeguard and control of these resources was without a doubt not possible. These "quarries" certainly did not foster the same value bestowed on other more rare lithic resources, such as mines of flint or precious metals.

10.2. Antiquity

In Antiquity, in spite of the absence of written documents, we perceive a new situation. The growing demand for volcanic querns and millstones resulted in a vast network of distribution over long distances. This would inevitably lead the ruling powers to retain authority over the quarries and, as in the case of the mining industries (iron ore, precious metals) or building stone quarries. It is reasonable to assume that these interest groups had a hand in the control of millstone quarries either through ownership and direct administration, leasing or imposition of tribute.

In the case of quarries in the countryside, far from the urban sphere, an outcrop like other natural resources, perhaps belonged to a nearby villa's master who retained the right to either exploit it by his own means or lease it to specialists. In any case, this is a possible model for the quern quarry of Châbles, Switzerland, based in the proximity of a villa (2,5 km) (Anderson *et al.* 2003: 59). This might also be the situation of certain Roman quarries in the south of Spain near rural settlements. The broken, unfinished roughouts at the settlements of Los Cazadores in Almería (Anderson *et al*. 2011: 153), Los Ceniceros, near Mazarrón, Murcia (Anderson *et al.* submitted) and near *Oretum* in Ciudad Real (Anderson *et al*. 2011: 161) link the settlements with the quarries and suggests that these workings, like other resources in the domain of the settlement were under its authority.

The volcanic quern and millstone quarry about 500 m outside the Roman city of *Sisapo* (CR-1) (Almodóvar del Campo), shares the outcrop with a large building block exploitation. Judging from their proximity of the city, it is plausible to imagine that both extraction sites (if contemporary), like other mineral exploitations in the area (notably silver and lead), were under the control of the authorities of *Sisapo*.

Some Roman quarries associated with defensive architectural features are considered to have been managed directly by the military (Gutiérrez 2009: 282). Following this line of thought, an argument could be made that certain quern exploitations might have been administered by the military due to their need of a great number of portable handmills for their army on the march. Military querns, at times carved with inscriptions, are known at Strassbourg, France; Saalburg and Xanten, Germany; and Vindolanda, England (Jodry 2011: 88-89). Direct control by the military or not, the armies of Rome presumably had access and authority, when needed, over quern production. All said, in spite of a large military presence in the Iberian Peninsula, no quern with a military inscription has been identified on Spanish soil.

Independent of the large Roman volcanic productions (and to a certain extent the *ostionera* production of the Atlantic coast in the Province of Cádiz), modest non-volcanic quarries were still in operation in Roman times, as seen through sandstone, limestone tufa and conglomerate querns brought to light in Roman contexts. These workings remained, nonetheless, at a local level. Surface blocks in riverbeds or taluses, or even detached from sandstone outcrops were certainly always an economical alternative to the imported volcanic querns. We can speculate that these lower-quality exploitations probably passed unnoticed by the authorities.

Fig. 10.1: General view and detail of the building stone sector of the volcanic quarry (CR-1) near the Roman city of Sisapo*.*

10.3. Islamic rule

The concept of millstone workings ownership under Islamic rule is particularly murky. In the years immediately after the Islamic conquest, properties such as mines (and presumably quarries) were only confiscated by the authorities in the regions taken by force (Serrano Ruano 2010: 193). In southern Spain, where most of the regions were transferred to Islamic rule by means of treaties, properties presumably remained in the hands of the original owners (Serrano Ruano 2010: 193). There is no evidence, at this time, of a large, profitable network of millstone commerce comparable with the earlier Roman long-distance trade of volcanic millstones. With the abandon of the volcanic rock and the adoption (or return to) of more widely available stones, such as conglomerates, limestones and sandstones, sources of millstones would have been omnipresent. The ever-growing demand for new watermills erected along a developing system of *acequias* (irrigation ditches) were probably met by local and regional exploitations. It is therefore plausible that millstone workings, like mines, remained under the authority of individuals or "tribal" units, and not under control of a central authority (Serrano Ruano 2010). As with other professions, such as millers, tribute was likely to have been demanded by the authorities (Lagardère 1991: 60).

10.4. Post-Islamic rule and the Modern period

In the Middle Ages, after the reconquest of present Catalonia, the highest authorities were directly interested in, and presumably maintained authority over, the production of the large millstone quarries at Montjuïc on the southern edge of Barcelona, a quarry that yielded sandstone for construction and millstones since at least the early 13th century until as late as the 20th century (as seen from photographs in chapter 1, fig. 1.4-1.5).

An archive from 1203 records that the monarchy was awarded tribute for each millstone that exited the port of Barcelona (Español 2009: 967). Gutiérrez, in her recent work on building stone quarries in northeast Catalonia, adds: "*The fact that during Mediaeval times quarrying at Montjuïc was protected by the kings gives you an idea of the importance of this industry, and in particular of millstone production*" (Gutiérrez 2009: 90-91). The monarchs in question, Kings Pere II, Jaume II and Pere III, maintained these interests by renewing the privileges granted to the stone cutters on three occasions in 1211, 1327 and 1338.

Elsewhere in the Iberian Peninsula, the later Christian reconquest left large sectors of the countryside without population. The ensuing "protection and transfer of property" was regulated by the authorities through codices called *Fueros* (Powers 2000: 57). The *Fuero de Cuenca*, dating to the rule of King Alfonso VII in the late 12th century, sheds unequivocal light on the question of ownership of millstone quarries:

"All the quarries, gypsum beds, ***millstone quarries****, tile works, and also the perennial springs should be common property of* ***the council****. Whoever has a millstone quarry or any of these things mentioned previously on a property of his should sell it to* ***the council*** *for a double-sized property, and it becomes communal. If someone occupies it against another of the council, he should pay a hundred* aurei*"* (translation by J. Powers 2000: 57).

The control of these resources by the council (*consejo)*, the highest unit of government under the monarchy, is not unique to Cuenca, as this *Fuero* is known to have served as a model for subsequent codices, such as that of Sepúlveda, yielding ownership of the natural resources to the authorities either through acquisition or by expropriation (Bermúdez Aznar 2005: 164).

The role of the church in the ownership of millstone quarries in this period is not clear. The sites of Cabra, Los Frailes (CO-1) and Monasterio de San Salvador in Guadalajara (GU-2), as their names indicate, were very near monasteries. Although we have not identified any evidence proving the church owned any particular millstone production centre, it would not be surprising that some fell under monastic authority so as to gain profit by leasing them. As is well established, the church received or acquired numerous properties through the years. The watermills in urban Córdoba in 1236, for example, were ceded by Fernando III to the clergy shortly after the reconquest (Cordoba de la Llave 1988: 827). Properties ownership by the church was so extensive over the years, that the state imposed a series of *desamortisaciones*, that is, "confiscations", to change their ownership, starting at the end of the 18th century. (We will elaborate on this question further ahead).

In the Modern period, after the fall of Islamic rule, resources, as well as quarries, were, as is the case of *Fueros*, in the hands of the councils. The residents of Antequera in 1501, for example, were outraged with the *Malagueños*, from the coastal city 30 km to the south, who intruded into their territory and appropriated their millstones (presumably the site of El Torcal, MA-1) without paying tribute. This rift ended in a legal bout that reached the highest court of the day, that of the Catholic Monarchs in Granada (Fernández López 1982: 222-223; AML, Leg. 49, p. 9. 1 cuartilla + 1).

An unquestionable example of the control of the authorities over millstone workings is seen through the ordinance of 1502 in the Municipality of Loja (Granada), served in the form of a *pregón* (oral proclamation). The regulation threatened a harsh punishment for any unauthorised extraction, that is, not only a fine and the confiscation of the millstone, but seizure of the oxen used for its transport (Pregón 1502, enero, 10. Loja, Pregón de la ordenanzas de Loja sobre no sacar piedras de molino. AML, Leg. 49, p. 9. 1 cuartilla + 1; http://www.teresadecastro.com/Fuentes/DocMunic/DOCLOJA.6.htm).

At Llerena (BA-2) in Extremadura, a similar municipal ordinance dating to 1566 prohibited "foreigners" from extracting millstones from the local quarry, unless they, like the locals, paid the official tariff (http://manuelmaldonadofernandez3.blogspot.com.es/2010_04_01_archive.html).

Even the highest authority showed an interest in rock quarries. King Philip II, in the middle of the 16th century, acquired the limestones quarries of Colmenar de Oreja (M-2), reputed for their excellent, hard white rock quality. The intention behind this purchase was to control the construction material destined for royal construction, such as the Royal Palace of Aranjuez. It is conceivable that if the millstone production was operative at that time, as it was two centuries later, it would also have come under the monarch's authority.

Yet another example dates to 1745, when, based on historical archives, the municipal authorities of Rota reinforced the prohibition of millstone extraction along the coast unless a tax, reduced to half of its original value, was paid (J. Martínez, Chronicler of Rota, pers. comm.).

A different angle to the question of millstone quarry ownership has been noted by P. Pascual and P. García, in their recent research in the region of La Rioja and parts of Castilla y León. They have pointed out that some workings are split up along present municipal borders (Pascual & García 2011: 291). Some of these divisions could, according to these and other authors, be deliberate attempts by the authorities to establish an equitable division of the quarries to avoid disputes between the different local authorities (Basterra 2003: 249-251; Maestro Hernández 2001: 24-28). This is the case, based on contracts drawn up in 1706 and 1744 (and others possibly since the 15th century), between different *consejos* in the Palencia mountains that sought out to regulate the size, quality and quantity of millstone production and avoid "excesses that would damage their commercialisation" (Basterra 2003: 250).

No such contracts between municipalities are known in our study area. Several quarries are, nonetheless, found along the boundaries of present municipalities, such as, for example, Castillo de Locubín (J-1), Loja, La Merced (GR-4); Miraflores de la Sierra (M-5) and Bohanal de Ibor (CC-4). It is obvious that the penning of contracts to avoid disputes between municipalites requires that the rock outcrop be extensive, as is the case of the puddingstone units in Palencia. We therefore doubt that production at Castillo de Locubín (J-1) and Loja, La Merced (GR-4), sites relatively restricted in space, were significant enough to merit having an influence on municipal boundaries. The only case in the south of Spain where a situation similar to that of Palencia could be conceived is at the vast granite fields at *Los Molares* (HU-8) in the Province of Huelva that stretches over the Municipalities of Almonaster la Real and Santa Ana la Real.

Not all millstone production was exclusively in the hands of the authorities in late Medieval times. In 1419, in the Province of Navarra, outside the sphere of the reconquered territories, a document records that María Ruiz de Arregui sold some of her mountain properties to the Monastery of Roncesvalles. The sale was concluded on the condition that she and her successors retain the right not only to exploit millstones, but to take as much wood as needed to remove the millstones (presumably to build sledges). Of interest is the accord was still in effect almost two centuries later, as it was renewed in 1634 (Pascual *et al*. 2001: 249). We ignore, however, if similar accords, permitting an unlimited access to a resource without possessing the land, existed in the south of Spain.

10.5. Contemporary period

The example of LLera (BA-3) in the Province of Badajoz (Extremadura) throws light on a different angle of the question of ownership. The Royal Census of Extremadura of 1791 records that the town did not possess any particular mineral worth noting, with the exception of rock outcrops for lime kilns and millstones (specifically flour mills). The document further states that these rocks are were the disposal of whoever needs them ("*... de las que se haze uso quien las nezesita*", Caso Amador 2008: 133). It is does not reveal, however, if a tax was levied for their use.

One of the rare cases identifying millstone quarry ownership in southern Spain is recorded in early 19th century by Cruz y Bahamonde. This distinguished traveller noted in his writings about commerce in the Province of Cádiz that the Berrueco quarry (CA-8) was the property of the Duke of Medina Sidonia, who received 18 millstones a year in exchange for the concession (Cruz y Bahamonde 1813: 91, note 1).

This noble family had a long history of ownership of mills and quarries. At least one watermill (Molino de La Teja) in the town of Vejer de la Frontera, about 20 km from Medina Sidonia, was their property from the beginning of the 16th century (http://www.patrimoniojandalitoral.es/f_vai_8.htm). In the early part of the 19th century, there are archives recording that the family also possessed a windmill in the town of Vejer (Molino de Santa Inés) equipped with Berrueco millstones 22 km away (http://www.wikanda.es/wiki/Molinos_de_Viento_de_Vejer_de_la_Frontera). The periodic replacement of millstones, especially the limestone models that had a very short life, could explain why the noble family demanded the lease be settled in millstones instead of currency. Furthermore, at this time, before the influx of French siliceous stones, the Berrueco stones were reputed to be the best in the region.

The ownership of siliceous millstone production in the Brie region of northern France, notably at la Ferté-sous-Jouarre, resulted in a rare social phenomenon labelled "*siliçocratie*", that is, a "rule" over the years by a series of millstone merchant families that amassed huge fortunes by exporting millstones throughout Europe and beyond (Belmont 2006, Vol. 2: 251). A similar situation, to a lesser degree, is documented at the quarry district of Selbu, Norway, where Frederik Birch, in the middle of the 19th century, acquired many sectors of the vast trench quarries and introduced new equipment, resulting in a lucrative business. Birch even went so far as to expose his product in the Universal Exposition of Paris in 1855 and 1878, as can be seen by diplomas exhibited in the Selbu Museum.

This phenomenon cannot be applied to Spain. Although some larger exploitations, like the Montjuïc in Barcelona, El Berrueco in Cádiz (CA-8) or the Cantera de los Frailes (CO-1) in Cabra, certainly afforded their owners a certain amount of prosperity, there is no evidence that this was comparable to the massive wealth, and social prestige that the "*siliçocratie*" afforded in the Brie of France (Belmont 2006, Vol. 2: 251).

As stated previously, it is well-established that the church accumulated numerous properties throughout the Medieval and Modern period. Judging from their ownership of many watermills, it would not be surprising that some millstone workings also fell under their control. We ignore, however, if any of these hypothetical quarries were affected by the *desamortisaciones* (confiscations), cited previously, of church properties that began in 1798, and continued periodically into the early 20th century. One of the more notable *desamortisaciones* took place in 1855 and is known as the *Desamortisación de Madoz*. This Minister of Revenue of Spain was the same Madoz who a few years earlier had penned the *Diccionario geográfico-estadístico-histórico de España* in 16 volumes (1845-1850), the most important source for identification of millstone quarries. We are left with the doubt, nevertheless, whether any of these sites recorded in the pages of the Madoz geographical dictionary passed from church to private hands.

10.6. Millstone quarry concessions

Throughout this chapter we have alluded to millstone makers leasing, in the form of concessions, sectors of quarries from the quarry owners. This notion is difficult to confirm through evidence in the field. At the Mont Vouan (Haute Savoie) in France, some side by side underground exploitations separated by thin boundaries could be interpreted as sectors leased by different work crews (A. Belmont, pers. comm.). The only site in our study area that shows any evidence of compartmental organisation that could correspond to different concessions is that of Cantera de los Frailes, Cabra (CO-1) in the Province of Córdoba, dated to Contemporary times (fig. 10.2).

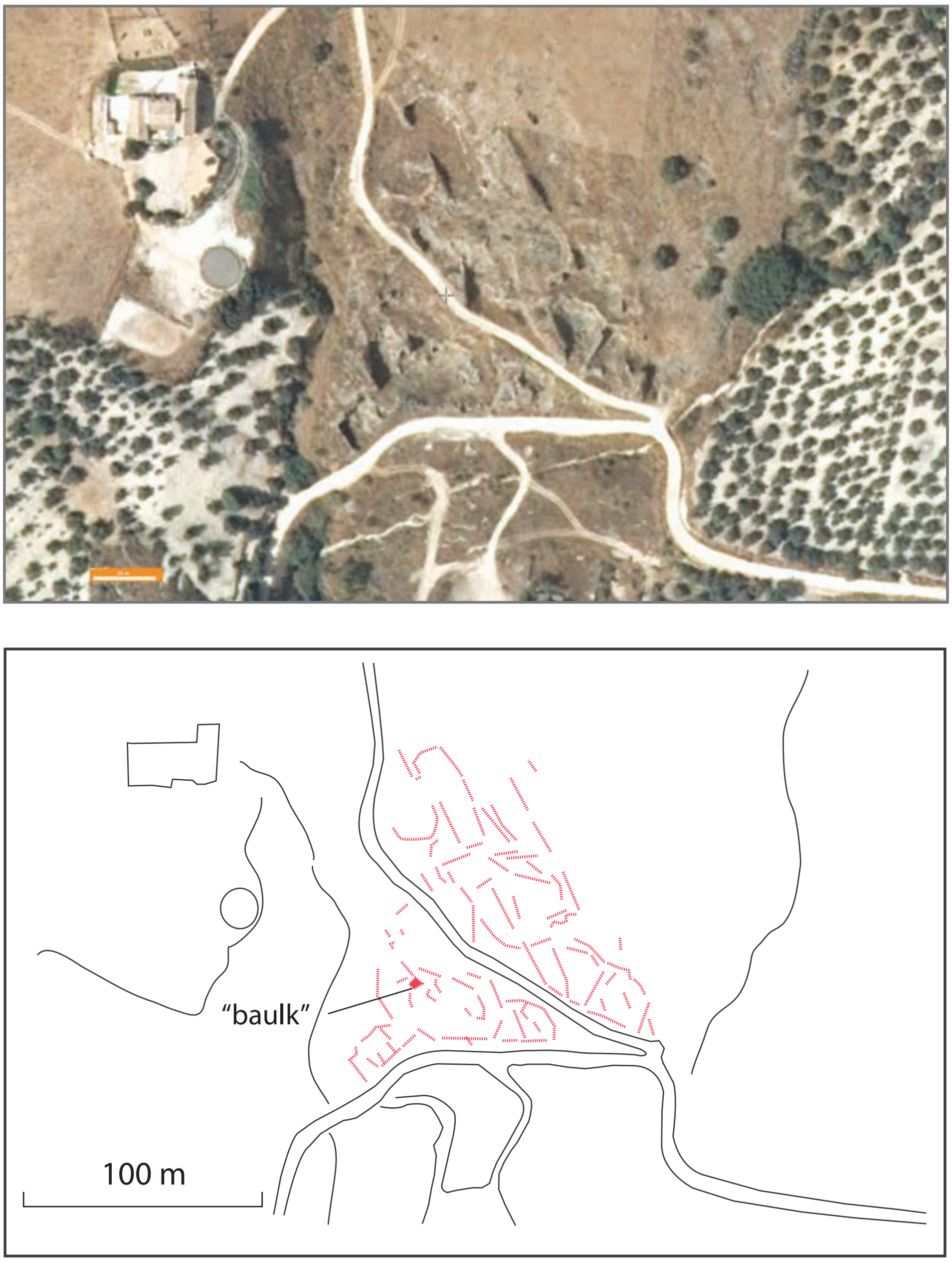


Fig. 10.2: Top: aerial view of the millstone quarry of Cantera de los Frailes, Cabra, Córdoba, The linear quarry faces seen to line up into compartments that could correspond to concession (SIGPAC).Bottom interpretation of the different linear interior limits of the quarry and the position of the "baulk".

From the aerial views it is possible to make out a certain internal divisions at the quarry based on a roughly orthogonal patters of quarry faces. In the southwestern sector there is an interesting vertical massive feature "baulk" (fig. 10.3), has observed at other open air Roman construction quarries such as that at *Sisapo* (see CR-1) and El Mèdol in Tarragona (Gutiérrez 2009: 156-157). These tall features (the *aguja* (needle) at El Mèdol reaches a height of 20 m after recent excavations, A. Gutiérrez, pers. comm.), with their rectangular or square floor plans, could, among other interpretations, correspond to boundaries between concessions.

The Cantera de los Frailes is one of the larger sites in the south of Spain. It is known to have exported its millstones as far as Málaga (85 km) (Ezquerra del Bayo 1856: 385) and Córdoba (60 km) (Montoro 2008). In this sense it would not be surprising that a number of millstone makers would have desired to have access to a sector of the site.

The situation of the millstone quarry of Fuentelárbol in the Municipality of Quintana Redonda (Soria) is quite unique from the point of view of concessions. On the outskirts of the town is a long, curved alignment comprising 255 millstones originating from a vast limestone quarry a short distance away (Fig. 10.4). The closest parallels, although anachronistic, are prehistoric megalithic alignments. Although the date of the feature is not recorded, the reference to its "excellent millstones" by Madoz (1847, Vol. 8: 216) places production at the quarry sometime

Fig. 10.3: Views of the Cantera de los Frailes. Top: views of the vertical "baulk" from the south and the east. Below: details of "compartments" that may have corresponded to concessions attributed to different millstone making crews.

before the middle of the 19th century. Folklore has it that this long, unique feature was a tribute to the municipal authorities. The story narrates that "young people who married and decided to stay in the town had the right to exploit a parcel of the quarry on the condition that the first millstone they produced be placed in the alignment" (Pascual & García 2010: 286). This was indeed a singular way to gain a concession and pay tribute to the local authorities.

Fig. 10.4: View of the alignment of 255 millstones in the Fuentelárbol (Quintana Redonda, Soria). Oral tradition has it that these millstones were a tribute to the authorities (photograph by P. Pascual and P. García).

11. MILLSTONE QUARRY CHRONOLOGY

11.1. Introduction

Millstone quarries, on the whole, were places of work and not permanent residences. In archaeological terms, these sites, in contrast to old settlements, are usually devoid of artefacts that allow the trained eye to date them. Even in the case of the few excavations undertaken elsewhere in Europe, the number of artefacts collected for dating is minimal. These sites are therefore very difficult to date.

To complicate matters, quarries (or quarry districts) can endure for centuries, even millennia. The *grès de la Serre* in the French Jura was scored between the Neolithic to Contemporary times (Jaccottey 2011). The *grès coquillier* of the Swiss Plateau, likewise, was exploited from the Late Iron Age until Contemporary times (Anderson *et al.* 2003). The white limestone of Claix (Charentes) and the hard arkose of the Mont Vouan (Haute Savoie), were scored at least since the Early Middle Ages and as recently as the 19th century (Belmont *et al*. 2001). Hence, a millstone quarry can have a number of different work phases spread out over a long period of time.

From our research in southern Spain, where no archaeological excavation of a quarry has taken place, the key to attain a more reliable dating of a site is to assemble the largest number of chronological indicators, as indicated in the figure 11.1. The principal indicators are old written sources and the typology of the abandoned products. However, since the abandoned products most often do not bear typological features, it is the morphometrics (dimensions) of the abandoned blanks or the hollows that become the indicators of chronology. Rock type is also an important indicator. It is becoming evident that certain rocks tended to be more pervasive in certain periods. Other potential indicators are the existence of *mola*-related place names, certain extraction techniques, the volume and nature of the products (homogeneous or heterogeneous), the geographical proximity to a dated feature and stratigraphy. Oral information, the tool of the ethnographer, can also serve to date the most recent production phases.

Yet, even in the best of cases, with a combination of indicators, millstone production centres often defy conclusive dating, and can, at best, only be placed in broad chronological niches.

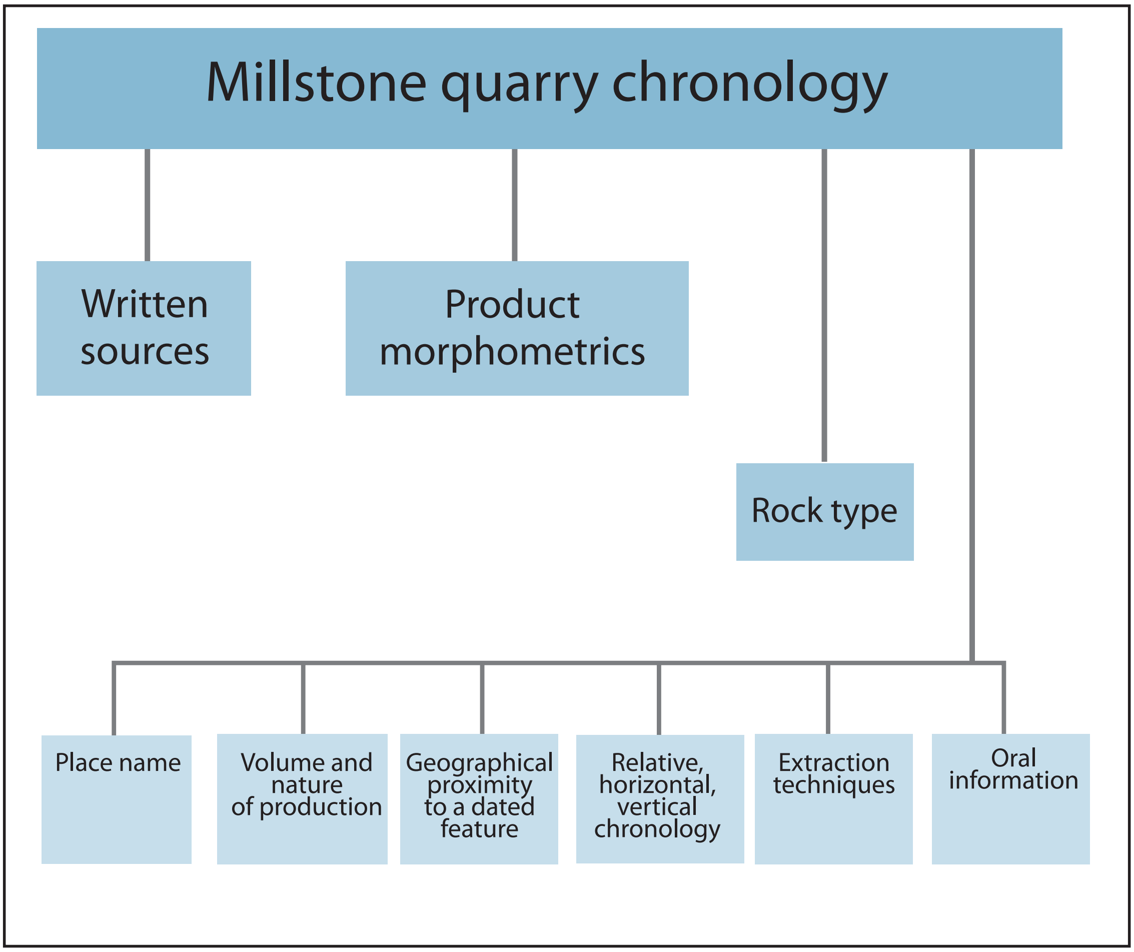


Fig. 11.1: Organisational chart with the hierarchy of the principal indicators to establish the chronology of millstone quarries.

11.2. Chronological indicators of millstone quarries

11.2.1. Written sources

Old written sources such as Royal Censuses, notarial protocols and historical, geographical and geological texts, are extremely useful to date millstone quarries (fig. 11:2). Without the information from the 19th-century geographical dictionaries of P. Madoz (1845-1850), and, to a lesser extent, S. Miñano (1826-1829), the number of sites in our study area would be rather slim. Sites in our study area pinpointed by old texts (61) make up more than a half of the total.

Most of these references were penned in the middle of the 19th century and reflect production in the first half of the century, before the outset of the Spanish Industrial Revolution and the arrival of the French siliceous stones. Historical records in the form of notarial protocols or municipal ordinances are in most cases older, dating as far back as the late 15th century. These documents are extremely valuable for identifying sites from the end of the Medieval period through Modern times. It must be noted that we have not identified these documents ourselves, but relied heavily on the research of the medievalist R. Córdoba de la Llave, who has uncovered a number of these early mill-related archive in the Province of Córdoba (1998, 2003, 2011).

The written sources, besides their role as chronological markers, often offer additional valuable information related to milling terminology, the grinding properties of millstones and their transport, facets that we have examined in previous chapters. These documents also reflect the personal bias or intention of their author. As we have mentioned in a previous chapter, it is possible that Madoz had certain political intentions when recording the presence of millstone quarries in particular geographical localities. It was Madoz himself, shortly after the publication of his 16 volumes (1845-1850), who headed the commission of one of the *desamortizaciones* that resulted in the change of hands of much property owned by the Church. These notions are interesting aspects that we are not in a position to judge for lack of data.

As valuable as they are, written sources are not conclusive and offer a truncated view of the life-span of a quarry. A citing of a site in an historical archive or a description in a geographical or geological text, reflects only a specific phase of a production, dating to when the text was penned. It does not throw light on earlier or later potential phases of work.

Written sources also do not clarify how long production had been in place. One of the rare "exceptions" is that of the geologist Ezquerra del Bayo, who, writing about the Cantera de los Frailes ,Cabra (CO-1), mentions that production had been going on for a "long time" (Ezquerra del Bayo 1856: 385). It is nonetheless difficult to measure if the term "long time" is a question of years or decades.

If we were to rely only on Madoz for the information about Moclín (GR-1), for example, it would date exclusively to the first half of the 19th century. The presence of a series of smaller quern and millstone models in certain sectors take the site back at least to Modern and Medieval times. In addition, oral information from a local *Moclineño* places workings in the early 20th century, much later than the Madoz reference.

A more precise idea of the life of a site is attained when it is described by several independent written sources. El Torcal (MA-1) and Loja (GR-2/3), for example, are each recorded in historical archives toward the turn of the 16th century (shortly after the fall of Islamic rule), and then, once again, in geographical texts of the 18th and 19th century. We can therefore surmise that their production continued, possibly uninterrupted, for at least four centuries.

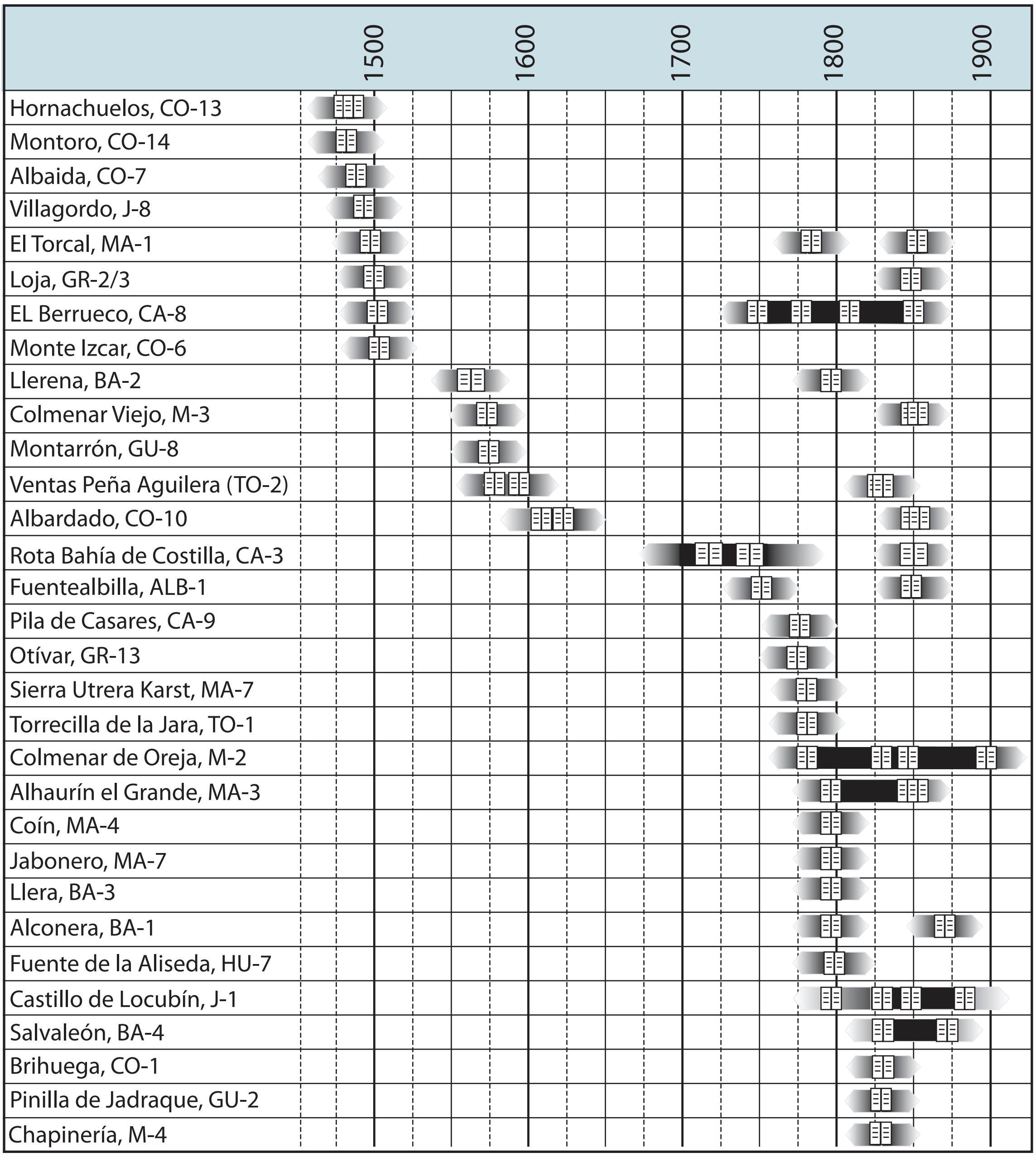


Fig. 11.2: Chronological chart of millstone quarries mentioned by old written sources between the end of the 14th century and the beginning of the 20th century. The symbol in the centre of the page represents the year of publication of the document. So as to reflect an estimated period of production, the arrows with grey gradients indicate (arbitrarily) 25 years before and after the year of the document. Some of the sites are cited in more than one reference resulting in a prolonged period of exploitation.

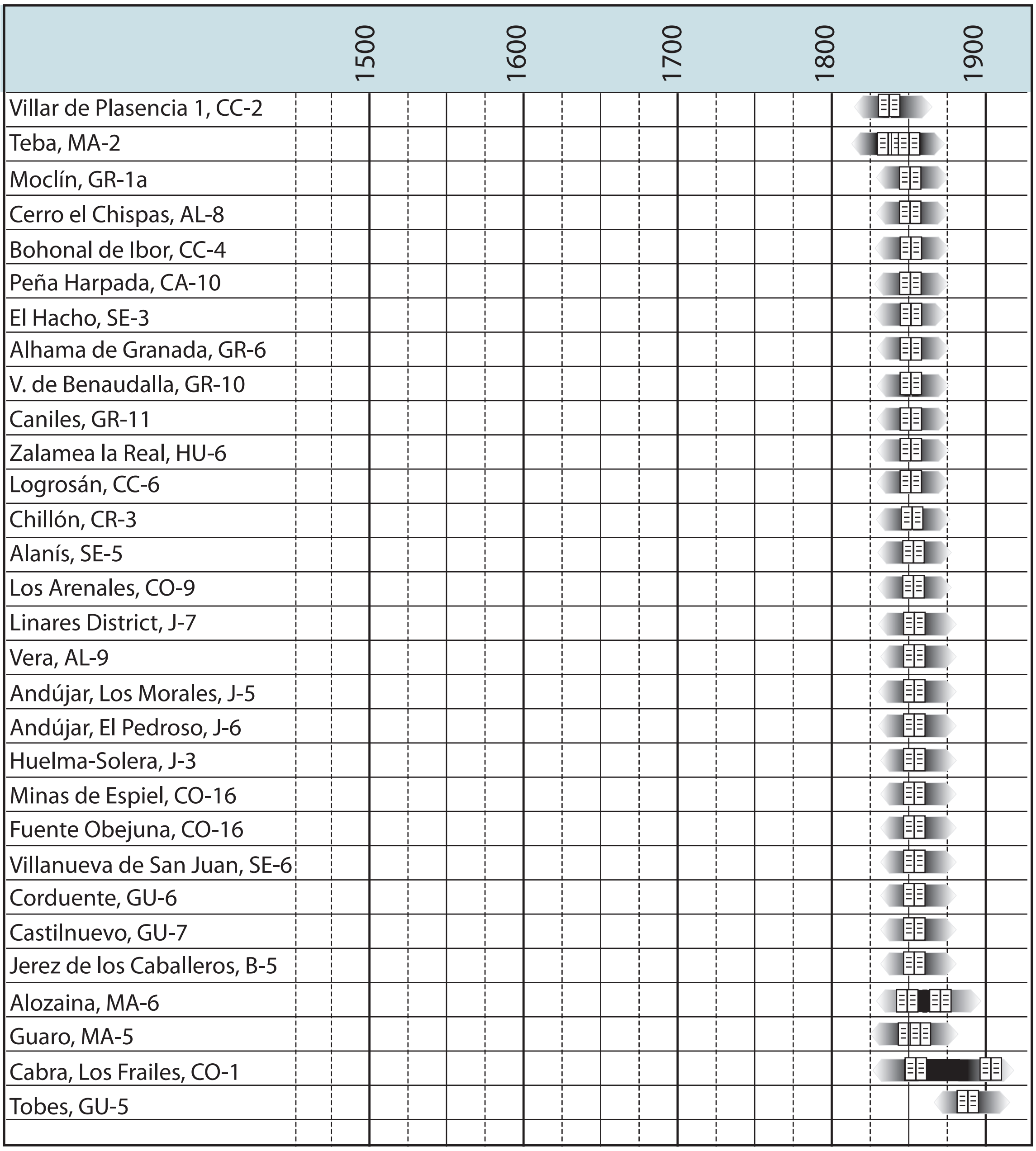


Fig. 11.2: (continued from previous page).

11.2.2. Morphometric indicators (millstone diameters)

The term "typology" in the case of millstones comprises three aspects: 1) form, 2) dimensions and 3) fittings. The problem with typology, in the context of millstone quarry research, is that the artefacts under study, cylindrical blanks and roughouts, are most often unfinished, hence almost always devoid of aspect 3, their fittings. These fittings, comprising cuttings for the driving (handles, levers, rynds) and centring (spindles, crosspieces) mechanisms, are very important elements in establishing chronology in finished millstones. So it is rare that the chronology of a quarry, even replete with roughouts, can be established by means of typology.

In these cases one must rely on the less precise morphometric aspects. At sites devoid of roughouts (often removed by collectors), the morphometrics of the cylinders can be reconstructed by measuring the diameter and height of the extraction hollow and then subtracting the width of the trench.

To establish the general morphometric indicator of chronology presented schematically in figure 11.7, we have conducted three analyses of millstone measurements presented in detail below. Two analyses, related to Antiquity and the Middle Ages, consist of measurements taken of the diameter of roughouts and extraction hollows at quarry sites in the Province of Almería. The third, related to the period ranging from the Late Middle Ages to Contemporary times is based on written sources.

Analysis 1

At the volcanic quern quarry of Cerro de Limones (AL-1) the diameter of 69 roughouts were measured. The line graph plotting these measurements reveals diameters ranging between 37 and 42 cm, with a peak at 40 cm (fig. 11.3). These measurements can be correlated with Roman productions because this is a rare example of a site that benefits from a few abandoned querns with typological features, such as radial slot cuttings on upper stones and "*sombrero*" lower stones. In addition the rock is volcanic, also an indicator of Roman chronology.

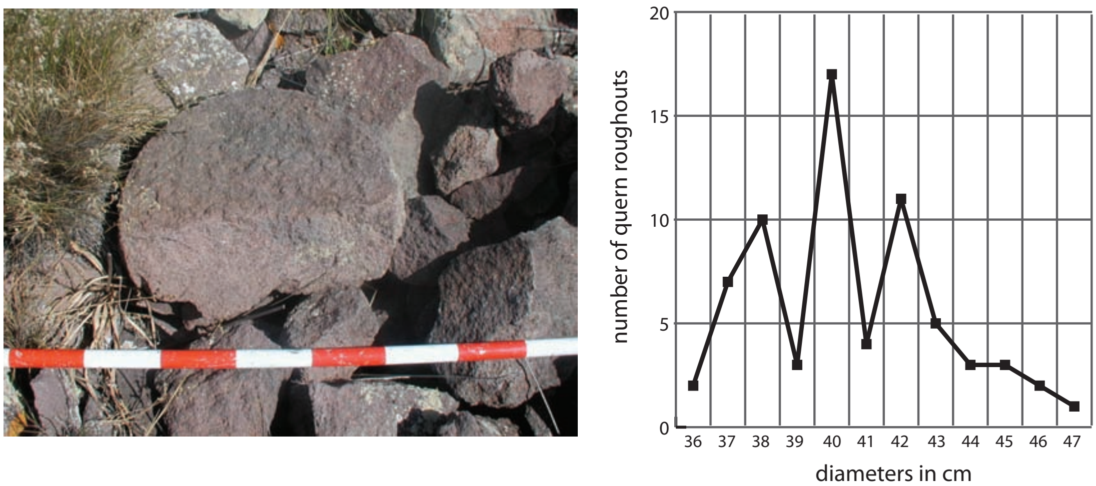


Fig. 11.3: Analysis 1: Line graph indicating the diameters of 69 roughouts and blanks measured at the Roman quern quarry of Cerro de Limones (AL-1). The graph shows a clear dominance of the diameters between 38 and 42 cm for these unfinished products.

Fig. 11.4: View of taking measures of the extraction hollows of the quarry of Rambla Honda (AL-3a) (photo graph by. F. Martínez).

Analysis 2

The second analysis consists of measurements taken at the coarse conglomerate (with large rounded clasts) Rambla Honda quarry (AL-3) in collaboration with F. Martínez and A. Gallegos (fig. 11.4). Here, since no roughouts were conserved, the diameter of 151 cylinders were extrapolated based on the measurement of the extraction hollows. These results, published in transactions of the Rome Colloquium (Martínez *et al*. 2011), show four basic millstone groups according to diameter (fig. 11.5).

The first group (a), from 40 to 50 cm, corresponds to a small set of rotary hand-querns. The second group (b) from 80 to 95 cm, presents a peak at 90 cm. The third (c), from 1,05 to 1,20 m, is more numerous (about a third of the total) has a peak at 1,15 m. The last group with the largest diameters (d), from 1,25 to 1,40 m, at a total of about 20 examples, is smaller.

From the chronological standpoint, the dating of the site is not precise (no typological features) and we are in no position to discern if the quarry had a prolonged life or not, and if all the extractions were contemporary. We can, nonetheless, glean the following chronological notions.

The few hand-quern extractions of group (a), from 40 and 50 cm, are considerably larger than the typical Roman querns at the Cerro de Limones (AL-1) of analysis 1. This size, added to the fact that they are thinner, point to a post-Roman date such as the few conglomerate querns reported at the Cabezo del Moro, a Medieval site in the Province of Murcia (Gutiérrez Lloret 1996: 205-207). Furthermore, there are no examples of Roman querns in museum depositories of this coarse conglomerate. An additional factor suggesting a post-Roman date is the absence, among group (b), of thick extractions that could correspond to Roman cylindrical mills, a type also unknown in this rock. The presence of a large number of discoidal extractions of groups (b) and especially (c), different from any known Roman mill, combined with the absence of a "*molares*" related place name, and no mention of the site in a historical document, lead us to believe that at least the core of this site, i.e. extraction groups (a), (b) and (c), is from the Middle Ages.

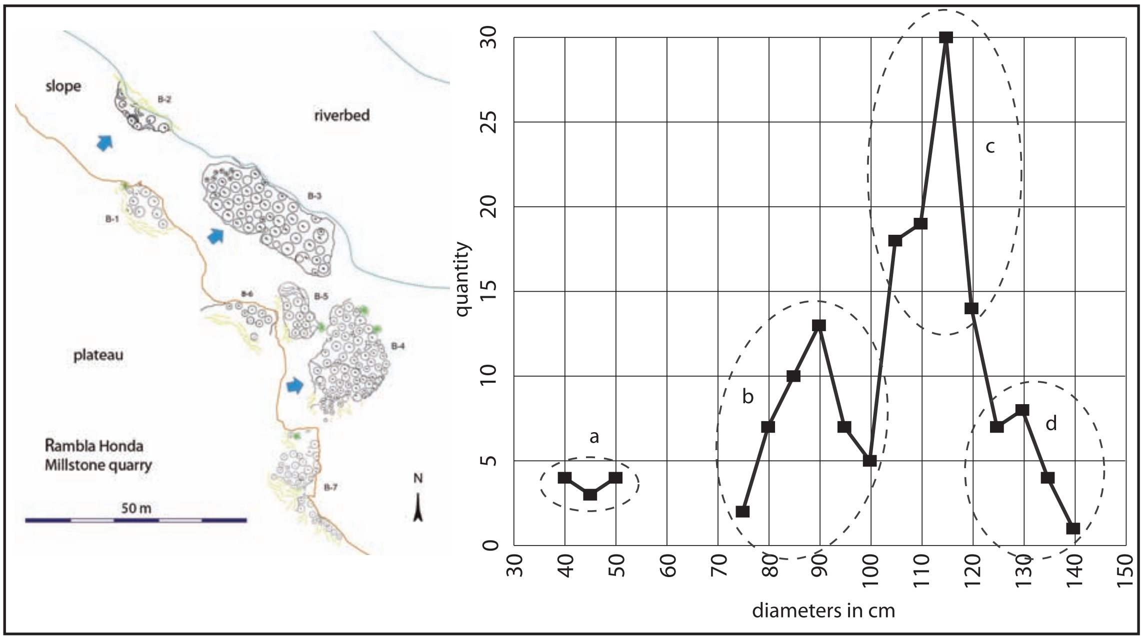


Fig. 11.5: Line graph of the diameters of 151 quern and millstone hollows measured in cm (from Martínez et al. *2011). Four diameter groups stand out at this site: a) from 40 to 50; b) from 80 to 95; c) from 105 to 120; d) a final group between 130 and 140 is more modest.*

Analysis 3

This third analysis, regarding the diameters of millstones from the Late Middle Ages to the Contemporary period, is based on historical written documents. We have compiled a list of sites, some of them quarries identified in our study area, of which we have knowledge of both the date and the diameter of the product (table 11.1). For example, from a historical archive of 1481, a millstone ordered from the quarry of Hornachuelos (CO13) measured a diameter of 8 *palmos* (1,68 m). In similar fashion, a notarial protocol of 1606 records that the Albardado (CO-10) produced millstones measuring 6 *cuartas* (1,26 m). The conversion of the former systems of measurement to the metric system is based on a Madrazo's table (Madrazo 1984: 226).

By correlating the date with the millstone diameters into a scatter graph (fig. 11.6), we observe the tendency of millstones, starting with the single case in the 12th century, to increase progressively over time, attaining between 1,40 and 1,70 m in the 16th century. At this time, the trend tends to reverse itself culminating in the 19th century with diameters ranging between 77 and 99 cm (Valero 1833). On the surface, this appears to be incoherent, especially if we compare these minute diameters with the contemporary extractions of Zone III of the French millstone quarry of Claix (Charente) that measure above 1,70 m in diameter. The size of the smallest group of Spanish mills can, however, be explained by the fact that they were scored at Colmenar de Oreja (M-2) and destined not to powerful watermills that could drive large stones, but to more modest animal-driven *tahonas* in the city of Madrid.

From this data, in spite of its low quantity of items and lack of statistical value, we can observe that dating millstones based solely on the measure of diameter can lead to confusion. The range of 80 to 90 cm, for example, is shared by some large Iron Age mills, by many Roman ring-mills (and Roman watermills elsewhere), as well as by Medieval millstones. So this diameter indicator is not always valid and must be considered in tandem with other indicators such as thickness and rock-type.

Table 11.1: List of written sources (historical archives or molinological publications) that correlated a date with the diameter (or range of diameter) of millstones.

Site code	Site or area	Type mill	Date	Ø (cm)	Unit of measure	Bibliography
-	Guadalbullón, Jaén	Watermill	1114	106	*4,5 empans*	Lagardère 1991: 109, note 105
-	Alcocer, Guadalajara	Watermill	1339	126	6 *palmos*	Martín Prieto 2006: 838
CO-13	Hornachuelos, Córdoba	Watermill	1481	168	8 *palmos*	Córdoba de la Llave 2003: 305-306, note 26
J-9	Villargorda, Jaén	Watermill	1499	147	7 *palmos*	Córdoba de la Llave 2003: 306
CO-6	Izcar, Córdoba	Watermill	1557	140	6 *cuartas y media*	Córdoba de la Llave 2011: 106
CO-10	Albardado, Córdoba	Watermill	1606	126	6 *cuartas*	González Peralbo, website
-	Puente Genil, Córdoba	Watermill	18th-19th c.	140	-	Esojo Aguilar 2011: 13
-	Murcia region	Watermill	19th c.	130	-	Cara Barrionuevo 1999: 155
-	Contraviesa, Almería	Watermill	19th c.	90	-	Cara Barrionuevo 1999: 155
M-2	Colmenar Oreja, Madrid	Tahona	1833	77-92	1 *vara*	Vallejo 1833: 387
-	Alpujarra Mts., Almería	Watermill	19th-20th c.	115-120	-	Cara Barrionuevo 1999: 155

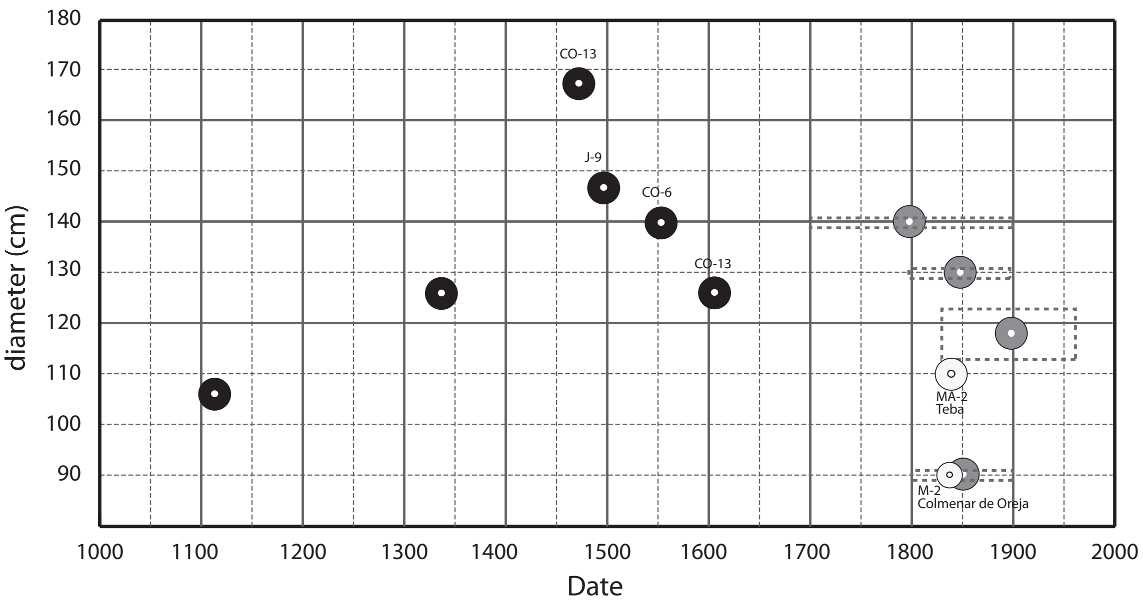


Fig. 11.6: Scatter chart illustrating the diameters of millstones recorded in written sources from the 12th to 19th centuries. The dashed lines indicate chronological (horizontal) and diameter (vertical) ranges where the data of the written source is approximate. The quarry sites, notably Teba (MA-2), are indicated by their code. The small circle is the quarry of Colmenar de Oreja (M-2), known for its production of small animal-driven millstones measuring from 77 to 92 cm.

The quarry of Teba (MA-2), Málaga, is particularly interesting from the standpoint of combining the diameter indicator with chronology. From the publication of three written sources (*Diccionario Geográfico Universal,*1833: 608; Madoz 1849, Vol. 14: 752; Espinosa 1848: 265), we can certify that production took place roughly in the first half of the 19th century. From our inspection of the site, we noted that the production was homogeneous from the standpoint of diameter, with no evidence of other work phases, and the dozen abandoned millstones measured systematically about 1,10 m in diameter (fig. 11.6). This range follows the tendency based on written sources seen in table 11.1 and fig. 11.6 revealing that "small" extractions, between 1,00 and 1,20 m, were being scored as late as the early 19th century. A series of other sites such as Vélez de Benaudalla (GR-10), Peña Harpada (CA-10) and El Hacho (SE-3), all cited by Madoz in the mid-19th century, are also littered with cylinders measuring between 1,00 and 1,30 m in diameter, corroborating that this diameter was standard in the middle of the 19th century.

From measurements collected at quarry sites, museum depositories and the little existing millstone literature, we arrive at the following morphometric indicators that serve to determine chronological tendencies.

Fig. 11.6: The dozen abandoned millstones from the site of Teba (MA-2) dated by written sources to the first half of the 19th century, such as the one in the photograph, measure on an average 1,10 m.

Four basic morphometric categories (fig. 11.7)

1- Extractions ranging in diameter from 35 to 42 cm most often correspond to Iron Age and Roman querns. Iron Age models are usually smaller that Roman models. Medieval querns, although generally larger than Iron Age and Roman models, are also known in this diameter range. The difference is that Iron Age and Roman querns, on the whole, are proportionally thicker than Middle Ages querns.

2- Thin, discoidal quern extractions 50 cm in diameter are associated, with a high degree of confidence, to the Middle Ages. Thicker models are animal fodder querns from Contemporary times.

3- The 60 to 90 cm diameter indicator is the most complex and covers all of the chronological periods. In general, Iron Age and Roman "drum" extractions in this range are for cylindrical mills that are as thick as they are wide. The tendency is for the Roman models to be slightly larger. Lower, discoidal models of this diameter are assumed to be either animal-driven or water-driven millstones ranging from to the Middle Ages to Contemporary times. This 60 to 90 cm dimension range, independent of other indicators, is not valid for dating millstones.

4- Millstones with the diameter of 1,00 m to 1,50 m, can date from at least the Late Middle Ages to Contemporary times. This wide range, although not very useful for dating, does permit discarding early periods such as Antiquity.

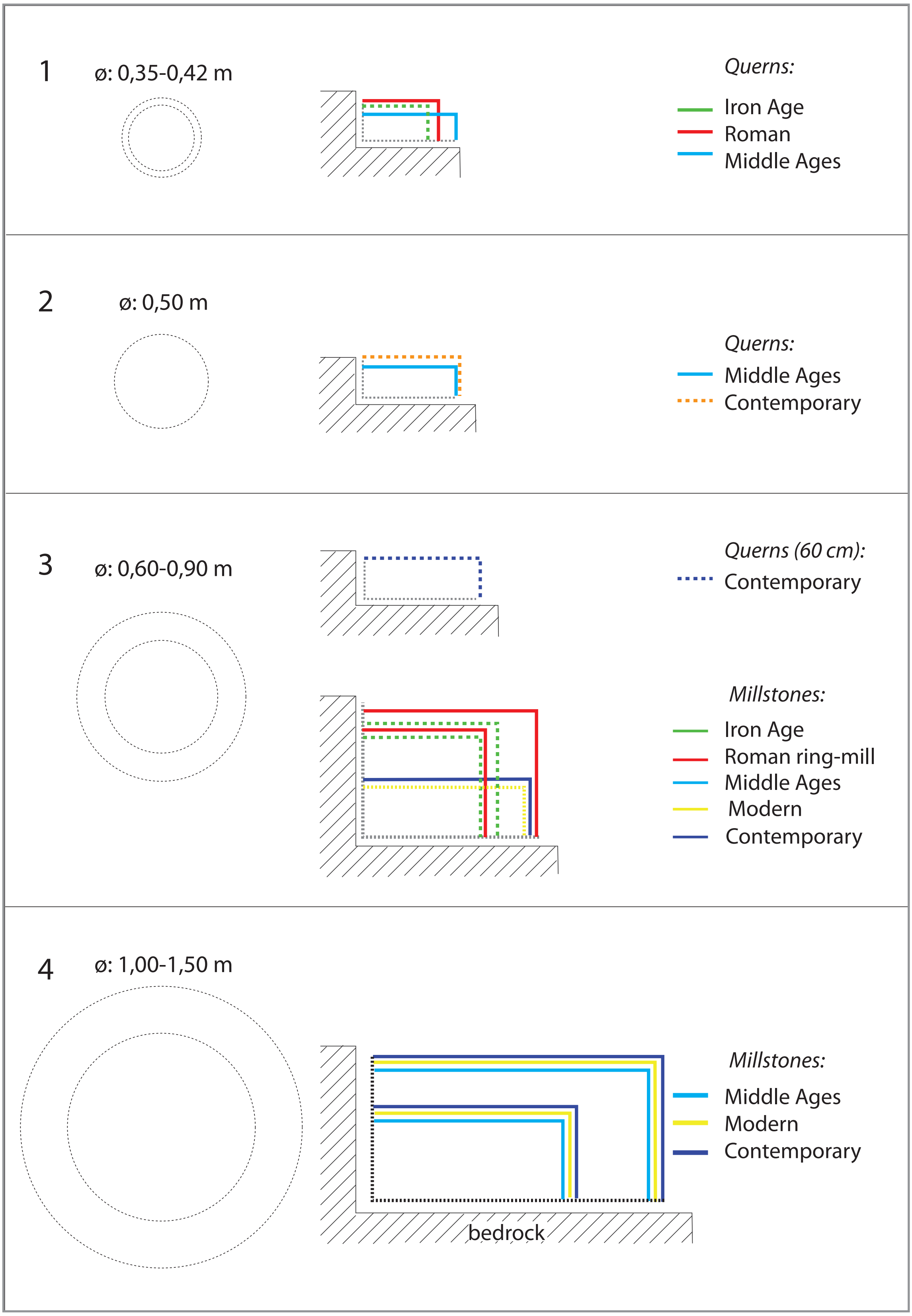


Fig. 11.7: Schema illustrating the four major categories of quern and millstone extractions (both cylinders and hollows) based on approximate proportions of diameter and thickness. The diameters of products overlap in the different chronological periods noted beside each drawing. This overlapping, especially in the case of 3, complicates the dating process. In these cases, other indicators are needed to establish the chronology.

11.2.3. Rock type indicator

The penchant for hard, porous volcanic rocks during the Roman period is well established. Basalts, andesites, and rhyolites outside our study area were exploited, for example, from Neolithic to Modern times in the Eifel of Germany (Harms & Mangartz 2002). Volcanic production centres are known throughout the western Mediterranean basin in Orvieto and the Veneto on the Italian mainland, as well as the Italian islands of Sardinia and Sicily (Antonelli & Lazarini 2010). In France these sources are in the Massif Central and Agde. Closer to our study area is the Farkhana outcrop in northern Morocco and the Olot-Garrotxa in Catalonia, known for its quern production from the Late Iron Age through Roman times (Peacock 1980; Williams-Thorpe & Thorpe 1987; Williams-Thorpe 1988; Portillo 2006).

Directly in our study area are the two volcanic districts: the Campo de Calatrava in the Province of Ciudad Real and the Southeastern Spanish volcanic district stretching from the Cabo de Gata in Almería to large parts of Murcia and even a small area in the Province of Albacete. As a result of our research of the last few years published or in press, these two districts have joined the list of Roman millstone production volcanic districts spread throughout Europe.

Since these rocks were so highly prized in Roman times, the probability is very high that a volcanic model dates to Roman times. Other rock types are also chronological indicators. Coarse conglomerates with large rounded clasts and hard white limestones, for example, are unknown in Roman millstone production. Fine white limestones in the south of Spain also tend to be associated exclusively with Late Medieval to Contemporary productions, as is the case of Moclín (GR-1a) and Berruecos (CA-8).

11.2.4. Other chronological indicators

Other indicators of chronology, although not as significative as the previous indicators, can provide notions as to the life span of a millstone quarry.

11.2.4.1. *Mola*-based place names

The toponym *molares* and other derivatives of the Latin *mola*, in our study area, postdate the Islamic domination and reflect the re-naming of certain tracts of land. In this sense, they can be used as a chronology indicator, placing them, roughly, at the transition from the Late Middle Ages to Contemporary times. However, as we have stressed previously, a site can be exploited over a long period. A *mola*-based toponym therefore cannot exclude millstone workings previous to the Christian Reconquest. We would, nonetheless, suppose that older sites that had already abandoned millstone production before the Reconquest, would not have been renamed with a *mola*-based name. In this sense, the absence of a *mola* place name can be an indicator of production in a distant past.

11.2.4.2. Geographical proximity to a dated feature

The proximity of the quarry to a well-dated feature can link it, at times, to a chronological period. The best example is the Roman *Sisapo*-Castillejo volcanic quarry (CR-1), a stone's throw from the Roman city of *Sisapo* (fig. 11.8). Other examples, such as the quarry of Zujaira (GR-12) linked to nearby Pensadores, and Las Rajas Prehistoric settlements, and the volcanic rough-outs of the settlements of Oreto y Zuqueca (Granátula de Calatrava, Ciudad Real) and Los Ceniceros (Mazarrón, Murcia) linked with the reputed exploitations at Cerro Columba (CR-6) and Cerro de Cabezo de Oliva (MU-2).

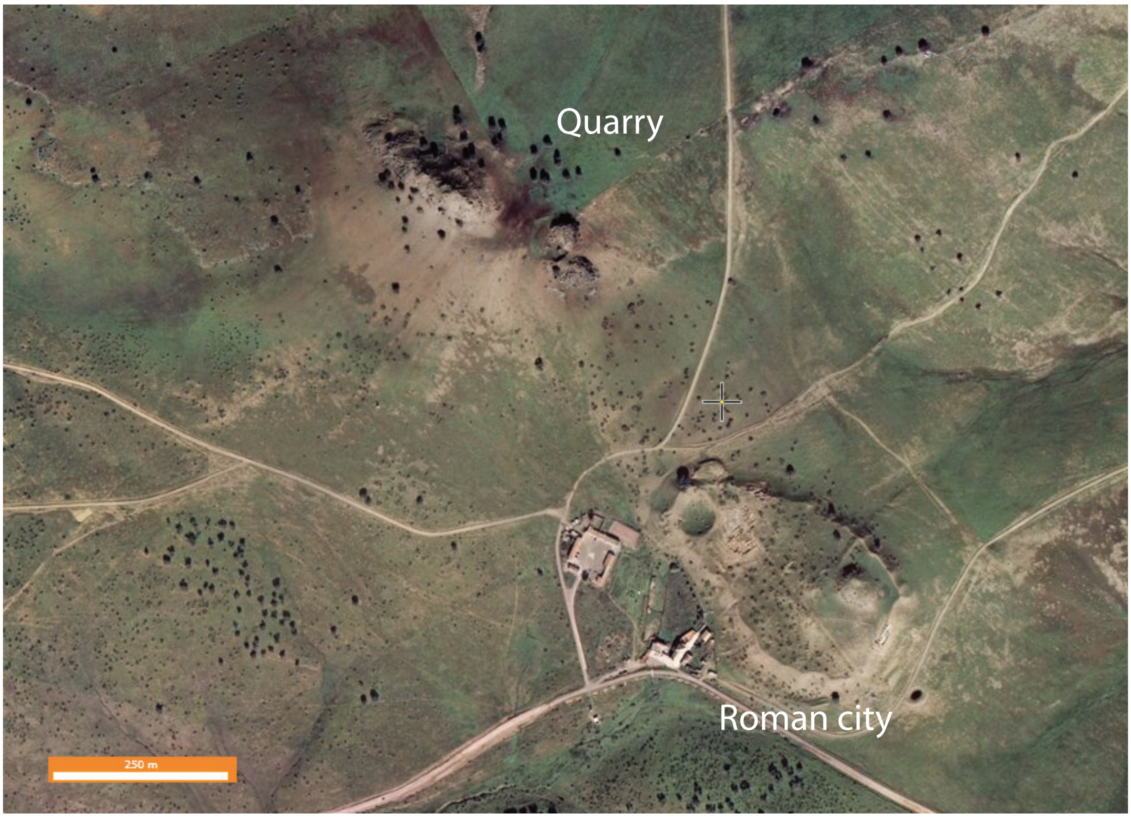


Fig. 11.8: Aerial view of the volcanic domes with the quern and millstone quarry (CR-1) showing the link by proximity (500 m) with the Roman city of Sisapo (SIGPAC).

11.2.4.3. Relative chronology and vertical stratigraphy

In the controlled context of an archaeological excavation of a settlements or cemetery, one can observe, for example, how a first, older pit or older tomb can be cut by a second, later pit or tomb. These are clear-cut examples of relative chronology. In millstone quarries, and other stone construction quarries, this stratigraphical relation also exists when the quarryman begins a new level of extraction by cutting through an existing quarry floor or vertical tube. At times this stratigraphical relation confirms there was a lapse of time a between extraction phases. This is especially interesting when the sizes and the extraction techniques of the two phases of extractions are different.

However, there is an exception to this rule. Small querns were at times cut directly into the heart of a larger abandoned millstone cylinders, as is a case at Zone I of the excavation of Claix (Charente) (Belmont *et al*. 2011: 206, fig. 5). The information gleaned from these cuttings is that querns were produced either simultaneously or after large millstones.

In this case the relation between these features excludes a Roman date (because large discoidal millstones are not known in Roman times) and suggests a Medieval date. In the case of Zone 1 at Claix, the Medieval date was confirmed by a thermoluminescence analysis of a potsherd (Belmont *et al*. 2011: 205). In our study area, there is also an identical case at the Puerto de la Cadena (MU-1) that will be essential in dating other similar sites.

The sole example of vertical stratigraphy in our study area is the relationship between a sector of the La Mola, Montesa quarry (V-2) and a Medieval fortification perched on the plateau directly above the quarry (cf. fig. 11.24). The fortification probably antedates the quarry because it appears not only to cut through the top of the tubular extractions, but for reasons of stability it would not have been wise to extract millstones along its base.

11.2.4.4. Extraction techniques indicator

Pick work evolved little over time. Detailed study of extraction techniques in the framework of a controlled archaeological excavation can, at times, provide evidence relative to dating. The chronology between Zones I and II of the site of Claix (Charente) was evidenced, among other things, by subtle differences of splitting techniques. The querns of Zone 1 were split by wedges placed in large, single trapezoidal holes, whereas those of the later Zone II were split by triangular (Belmont *et al*. 2011: 205-207). In our study area, extraction techniques are rarely visible. This indicator is therefore only valid in very specific cases, such as the Medieval quarries of Zagra (GR-5) and Almaden de la Plata (SE-1a/b), where the tool marks are still visible.

11.2.4.5. Oral information

Oral information, in particular, the memory of descendents of millstone makers, can be very useful to date at least the last phases of workings of certain sites, such as Moclín (GR-1), Benaocaz (CA-12) or Playa de Agua Dulce (CA-4). As we have seen, the study of Maestro Hernández (2011) on the millstone quarries in the mountains of Palencia, based a large part of his work on interviews with the descendents of the *moleros* that appear in a black and white photograph dating to the 1930s.

All of these different chronological indicators, applied independently, do not suffice to establish even an approximate date for quarries. Even so, they do serve to reinforce or corroborate the other stronger chronological indicators.

11.3. The chronology of millstone quarries in southern Spain

11. 3.1. Introduction: The chronological assemblages

To illustrate the dating of the millstone quarries, we have divided them into three assemblages, represented in three tables. Each assemblage, described and summarised below, is developed further in the coming pages.

Chronological assemblage 1 *(see table 11.2)*

This table presents the earlier quarries in chronological order based on their earliest reputed phase of production. These are for the most part Prehistoric, Iron Age, Roman and Medieval productions of saddle querns, rotary querns, cylindrical mills, and small millstones. Some of these sites, for example, Rota (CA-3), Moclín (GR-1) and Castillo de Locubín (J-1), have later chronological phases that are identified through texts. The indicator of the rock type, especially in the case of Roman sites, plays an important role in establishing the chronology of these sites.

Chronological assemblage 2a and 2b *(see table 11.3a and table 11 3b)*

This assemblage is established exclusively from written sources and is illustrated in two tables separated by a hiatus of about 30 years. The chronology is founded on the earliest known extractive phase of each site. Instead of the less precise, traditional chronological units, the tables are divided into more precise columns by centuries. The first assemblage (2a) (table 11.3a), presents the older quarries from sources dating from 1481 to 1794 and corresponding broadly with the Modern period. This first assemblage is divided into four subgroups (a, b, c, d).

Assemblage 2b, although a continuation of the first, is marked the transition to Contemporary times. Most quarries of this assemblage are those cited in the dictionaries of Miñano (1826-1829) and Madoz (1845-1850). Here are also included the few sites from the end of the 19th or beginning of the 20th century, dated from other written or oral sources.

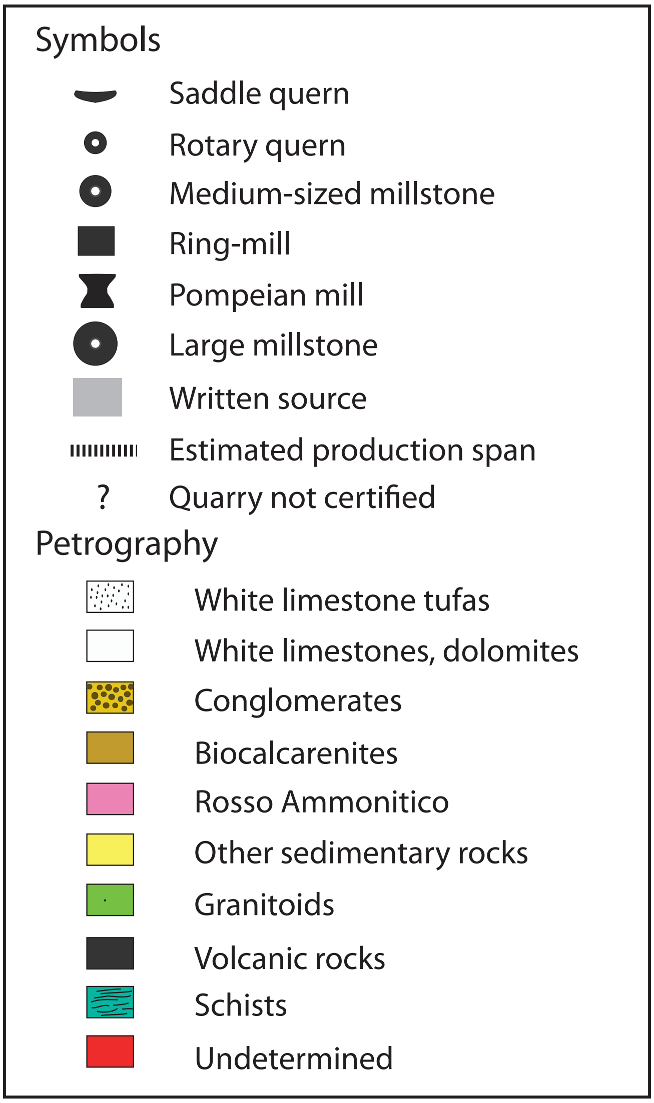
Chronological assemblage 3 *(see table 11.4)*

This last table records the approximate dating of the remaining millstone quarries that do not benefit from any means of dating except for the morphometrics of their extractions and extraction hollows. From our observations in the field (the first 9 sites on the list) and from photographs from hiking itineraries or historical internet websites, we gather that the production consisted of cylinders over 1,00 m in diameter and therefore date from anytime between the Middle Ages and Contemporary times. We cannot excluded older working phases at the sites we have not been able to visit. Here, due to the lack of chronological precision, we are constrained to use broad chronological units as in the case of the first table.

The following is a list of the symbols are used in the tables. The different colours, the same as in the geological chapter, indicate the petrography.

As future millstone quarry research progresses, the chronology of many of these sites will be refined, completed and corrected. One of the objectives of our study is to pave the way for this future work.

The explanations of the indicators for each table a explained in the following pages. Those of assemblage 1 are much more complex and require much more ink than those of assemblages 2 and 3 that are more straightforward.



Symbols used in the different chronological tables.

11.3.2. Chronological assemblage 1

This assemblage comprises 31 sites dating from Prehistory to th (table 11.2)

11.3.2.1. Prehistoric and Early Protohistoric quarries

The typology of saddle querns found at or near the quarries where they were scored, date the three Prehistoric or Early Protohistoric quarries identified in our study area. Of the three, only El Barronal (AL-10), in the volcanic fields of Cabo de Gata, has extraction features in the form of pits where, presumably, the summits of columnar jointing were detached in the form of small blocks to be fashioned into saddle querns. The chronology of these features is corroborated by surface finds, notably pottery and other stone artefacts, dated *grosso modo* from the Chalcolithic and the Bronze Age (Carrion *et al*. 1993).

The second site, Cabezo de la Oliva (MU-2), also of volcanic rock, was identified by a saddle quern surface find from the 1970s by S. Agüera (Agüera Martínez *et al*. 1999). Unfortunately, there are no other dating indicators for this site except that it was a potential source for querns in Roman times (see below).

The presumed yellow sandstone quarry of Zujaira, Granada (GR-12), is dated by saddle querns (and other lithic material of identical rock) brought to light recently at two nearby Prehistoric settlements (fig. 11.9). A first Late Neolithic extraction phase of the quarry is corroborated by saddle quern findings associated with coarse globular vessels and flint at the settlement of Los Pensadores. A later Chalcolithic phase is based on querns associated with large, low carinated vessels and fine, barbed, flint arrowheads at Las Rajas (Anderson 2010, unpublished report). This quarry, as we will see below, is also possibly the source of Roman rotary querns.

Fig. 11.9: Example of a complete saddle quern recovered in the backfill of a silo at the Late Neolithic settlement of Los Pensadores. The source of the yellow sandstone is presumably the nearby outcrop of Zujaira (GR-12).

Table 11.2: Chronological table of millstone quarries from Prehistory to the Middle Ages. This chart illustrates, for the most part, sites that are not recorded in written texts. The site of Rota (CA-3), Moclín (GR-1) and Castillo de Locubín (J-1), identified by written sources, appear in this chart because of their older quern extraction phases.

Code	Site	Certified	Neolithic Chalcolithic Bronze Age	Late Iron Age	Roman	Middle Ages	Modern	Contemporary
AL-10	El Barronal	no						
MU-2	Mazarrón	no	?		?			
GR-12	Zujaira	yes	?		?			
CO-15	Almedinilla district	no		?	?			
AL-1	Cerro de Limones	yes						
AL-2	Hoya del Paraiso	yes						
CR-1	Sisapo	yes						
CR-2	Las Herrerías	yes						
CR-6	Cerro Columba	no			?			
AB-2	Cancarix	no			?			?
CA-1	Trafalgar	yes						
CA-3	Playa de Costilla, Rota	yes						
CA-2	Pta. Camarinal/Pta. Paloma	yes			?			
MU-4	Fortuna	no			?			
BA-6	Mérida district	no			?			
SE-7	Gerena District	no			?			?
CO-11	Piedras Moleras	no			?	?		
CC-3	Villar de Plasencia 2	no						
A-2	Barranco Molinos, Ibi	no						
GR-5	Zagra	yes						
SE-1a	Almadén de la Plata	yes						
SE-1b	Almadén de la Plata	yes						
SE-2	El Pedroso	yes						
GR-4a	La Merced 1	yes						
MU-1	Puerto de la Cadena	yes						
AL-3a	Rambla Honda	yes						
AL-3b	Los Leonardos	yes						
GR-4b	La Merced 2	yes						
V-2	Montesa, La Mola	no						
GR-9	Playa de Carchuna	yes						
HU-8	Almonaster, Los Molares	no				?		
AL-8	Cerro el Chispas	yes						
J-1	Castillo de Locubín	yes				?		
GR-1a	Moclín	yes						
CO-12	El Patriarca	no						

11.3.2.2. Late Iron Age rotary quern and millstone quarries

Although not identified in the field, the chronology of the exploitation of limestone tufa or travertine quarries in the surroundings of Almedinilla (CO-15) is established with a high degree of precision towards the middle of the 2nd century BC. This dating is based on the presence of rotary querns and larger millstones at the stratigraphically secure excavation of the settlement of Cerro de la Cruz. It was, in fact, a Roman military incursion that brought about the settlement's sudden, violent end (Quesada *et al*. 2010).

On account of the burning of the site, a group of millstones remained *in situ*, at times on their original podiums (fig. 11.10). Their typical handle cuttings and lugs correspond to driving mechanisms known at other well-dated Iron Age sites in the northeast of the Iberian Peninsula (e.g. Alonso *et al*. 2011). The rock type is also perfectly compatible for this period.

Fig. 11.10: The limestone tufa (travertine) Late Iron Age production is dated by a series of millstones discovered in situ *at the well-dated Iberian Culture settlement on Cerro de la Cruz, by Almedinilla (photograph left: http://www.rutasconhistoria.es/loc/poblado-ibero-el-cerro-de-la-cruz); photograph right by T. Anderson).*

11.3.2.3. Roman quern and millstone quarries

Dating rotary quern and millstone quarries from Antiquity relies first and foremost on the comparison of the abandoned quarry products with artefacts in museum collections. The high number of Roman millstone finds, comprising rotary querns, cylindrical mills and a few Pompeian mills, constitutes a reference group large enough to date the grinding material broadly to the Roman period. To advance a finer dating at this stage of the research, however, is not possible due to the absence of chronologically well-defined assemblages.

A second general chronological indicator is the propensity of the Romans, throughout their conquered territories, to focus exploitation on volcanic rocks (basalts, andesites, rhyoliges and lamproites).

Roman volcanic quern and millstone quarries

The quern quarries of Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2) in the Cabo de Gata, on the southern edge of the SE volcanic district, are dated to Roman times by the typology and morphometrics of the numerous broken roughouts abandoned at the site (Anderson *et al*. 2011: 156-157). The first is a dacite quarry while the second, based on macroscopic analysis, falls broadly into the dacite-rhyolite sphere. A typological feature linking querns from the quarry of Cerro de Limones with examples in museums is an upper stone with traces of a radial handle slot cutting. But it is especially the "*sombrero*" type lower stone (fig. 11.11), represented by numerous discarded roughouts, that connects this production with Roman querns stored in different museums throughout southeastern Spain.

*Fig. 11.11: Unfinished querns at the Cerro de Limones dacite quarry. The radial cutting and "*sombrero*" protuberance are examples of typological indicators of Roman chronology.*

*Fig. 11.12: The "*sombrero*" type lamproite lower stone from the Roman villa of Los Ceniceros, Mazarrón (Murcia), dates to Roman times. The source is presumably the Cabezo de Oliva, the nearest lamproite outcrop (3 km away).*

It is reasonable that the volcanic (lamproite) site of Cabezo de la Oliva (MU- 2) near Mazarrón, Murcia (cited above for its potential as an older source of Prehistoric querns), included a Roman phase. This is based on several quern roughouts recovered at the nearby Roman villa of Los Ceniceros, notably an unfinished "*sombrero*" type lower stone (fig. 11.12) that is typologically equivalent to the Cabo de Gata production.

The volcanic quarry of *Sisapo* (CR-1) (Anderson *et al*. 2011: 159-161) in the volcanic district of Campo de Calatrava of central Spain, is dated to Roman times by a series of indicators other than that of petrography. First are the sizes of the extractions (40 cm and 80-90 cm), corresponding

Fig. 11.13: Abandoned cylindrical drum measuring about 80 cm in diameter from the quarry of Sisapo. The circular cavity on the upper face indicatives that it is an aborted Roman ring-type upper stone (photograph from Fernández et al. *2002: 121, fig. 6: 4).*

respectively to Roman rotary querns and cylindrical mills (Anderson *et al*. 2011). Unfortunately, no discarded roughouts were visible during our visit. Nonetheless, in photographs published in an archaeological study of *Sisapo* (Fernández *et al*. 2002: 121), there are examples of both rotary querns and cylindrical mills from the quarry, notably an aborted ring-mill (fig. 11.13). The proximity (500 m) of this quarry to the Roman city is also an indicator for dating the site to Roman times.

The quarry of Las Herrerías near Bolaños de Calatrava (CR-2), also in the Campo de Calatrava volcanic district, is a nephelinite olivine or olivine melilitite lava. The original extraction features have been destroyed by modern workings. A millstone production dated to Roman times is certified by 10 abandoned roughouts, miraculously set aside by the present day quarry workers (Anderson *et al*., in press) (fig. 11.14). All of them bear morphometric features characteristic of cylindrical mills identified on Roman settlements throughout southern Spain. Among the lot there is a fine example of a "*Volubilis*" type ring-mill (no. 10), a name coming from the Roman city of *Volubilis* in northern Morocco (Akerraz & Lenoir 2002).

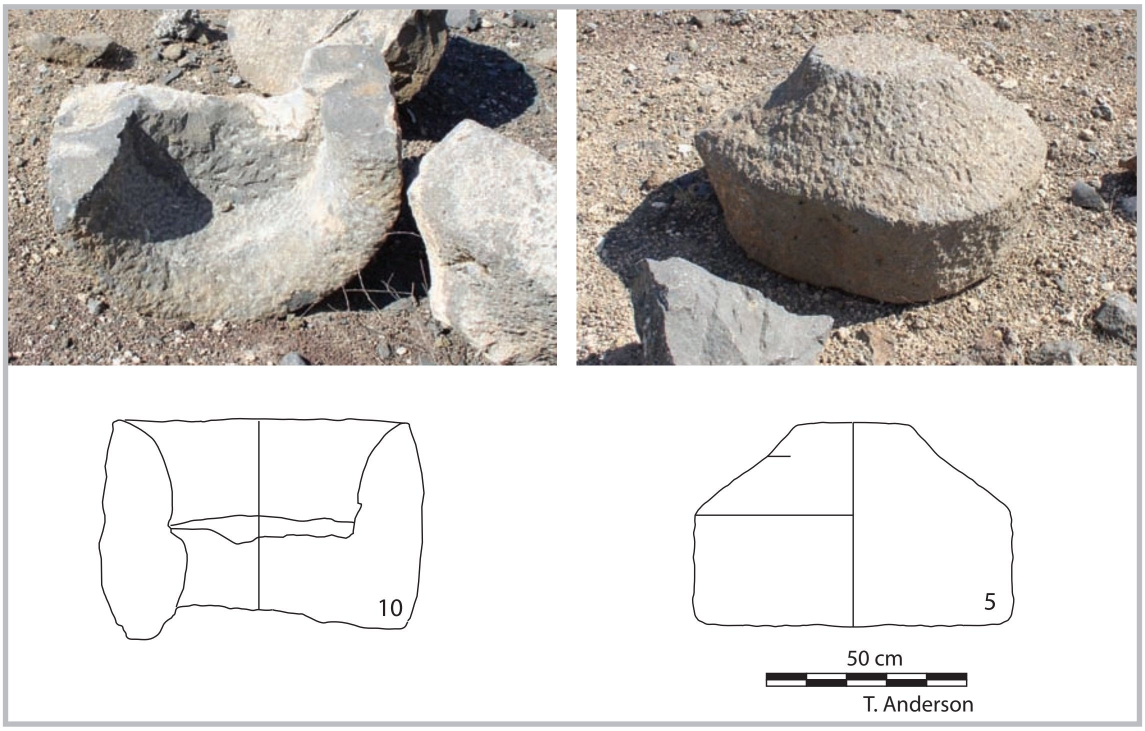


Fig. 11.14: Examples of unfinished millstones from the volcanic quarry of Las Herrerías, near Bolaños de Calatrava. No. 10 is a broken ring-catillus and no. 5 is a conical lower stone, types that are characteristic of the Roman period.

The Cerro Columba (CR-6) in Granatula de Calatrava (Anderson *et al*. 2011: 159-161), a volcanic dome on the banks of the Jabalón River in the vast Calatrava Volcanic district, is presumed to be the source of the construction material of a Roman bridge (Alañon Flox 1982: 230), now also under the waters of the Jabalón Dam. A Roman quern production is inferred at this site from roughouts and blanks measuring between 38 and 40 cm in diameter at the nearby site of Oreto y Zuqueca (fig. 11.15). These roughouts come either from the older Roman levels or were recycled as construction material in later Medieval constructive phases.

Fig. 11.15: Examples of unfinished or broken volcanic rotary querns at the Roman and Medieval settlement of Oreto y Zuqueca, presumably from the quarry of Cerro Columba (CR-6), a nearby volcanic dome. The sizes of the half-dozen unfinished querns, ranging from 38 to 40 cm, point to a Roman production.

The Pitón de Cancarix (AB-2), a volcanic (lamproite) outcrop in the Sierra de las Cabras (Albacete), could date to Roman times because it is presumably the source of millstones discovered at the neighbouring Roman settlements of La Horca and El Tolmo in the Minatda-Agramón Valley (Jordan *et al.* 1984: 222-223, 227). The prominent columnar jointing of this volcanic outcrop could have been exploited for querns or millstones, as was the case of volcanic sites elsewhere, notably in the Eifel of Germany (Harms & Mangartz 2002). Future field work should focus on confirming the Roman workshops at this site.

It is worth noting that this site was also reported to have also been exploited in very recent times (19th or 20th century?) for cobblestones and rotary hand-querns. These recent mill productions are probably animal fodder querns, and could still be seen until very recently, in nearby *cortijos* (Jordan 1997: 17).

Roman millstone quarries of other rock types

Roman biocalcarenite (ostionera) quarries: In the southwestern sector of our study area, far from the volcanic districts, the Romans developed a large production of the shell-rich, highly porous and abrasive, biocalcarenite (*ostionera*) rotary querns, scored from a series of outcrops along the Atlantic coast in the Province of Cádiz. Two of these sites have been identified at Trafalgar (CA-1) (Anderson 2011: 231-232, fig. 2-3) and Rota (CA-3). These sites, devoid for the most part of abandoned querns, are comparable to querns brought to light on Roman settlements in the region. About 40 examples of small *ostionera* querns, for example, are stored in the depository of the *Baelo Claudia* centre, of which 29 are sufficiently well-conserved to accurately measure their diameter (fig. 11.16).

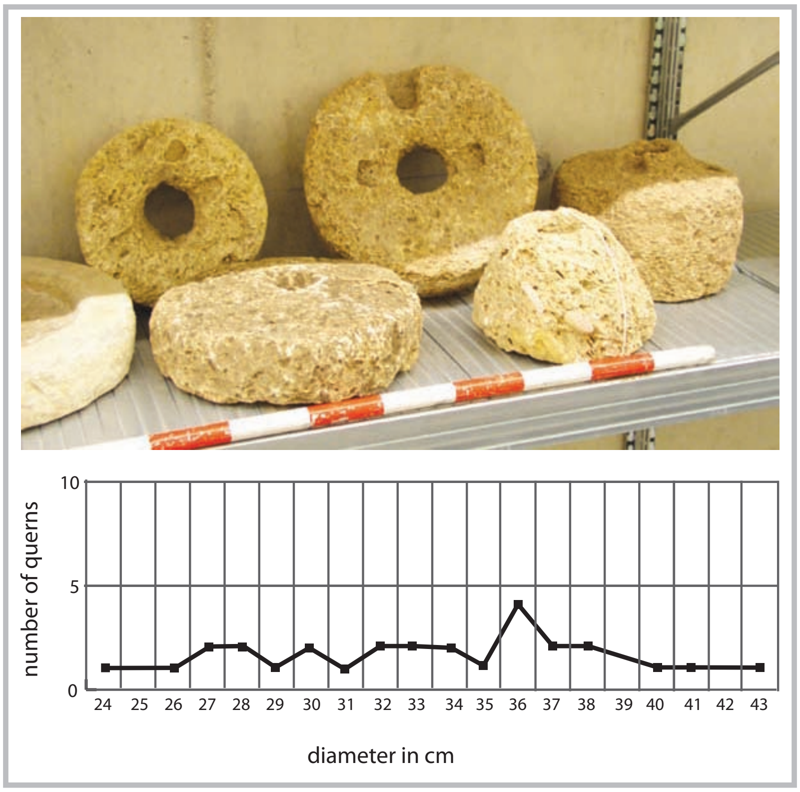


Fig. 11.16: Examples of ostionera *querns from the Roman city of* Baelo Claudia*. The hand-querns present a wide range of diameters (average at 33,5 cm), as seen in the line graph of 28 samples.*

The line graph of these querns displays a wide range of diameters from 24 to 43 cm with an average of 33,5 cm. It is worth noting that the *ostionera* Roman querns are significantly smaller than their Roman volcanic counterparts. All the same, they remain perfectly compatible with the extraction hollows at the quarries and confirm the Roman dating of the quarries.

Other examples of Roman *ostionera* querns compatible with these coastline quarries come from settlements near the Straits of Gibraltar, notably the Roman cities of *Carteia* (pers. comm. Salvador Bravo) and *Iulia Traducta* (Vargas & Bernal 2009: 179: fig. 24; Domínguez & Bernal 2011: 454, fig. 4). Excavations at *Iulia Traducta* brought to light 11 *ostionera* querns in the context of the fish industry (fish flour) dating to the 5th-6th centuries AD.

Roman *ostionera* millstone production was not limited strictly to querns, as evidenced by an unfinished "hour-glass" Pompeian upper stone recovered during excavations at *Baelo Claudia* (fig. 11.17). This unquestionably Roman stone, probably a copy of an imported volcanic model, is an isolated case. It is, for the moment, the only known example to have been produced on Iberian soil (Anderson *et al*. forthcoming). It was most likely scored from recycled construction material from the nearby Roman block quarries of either Punta Camarinal (CA-2a) or Punta Paloma (CA-2b).

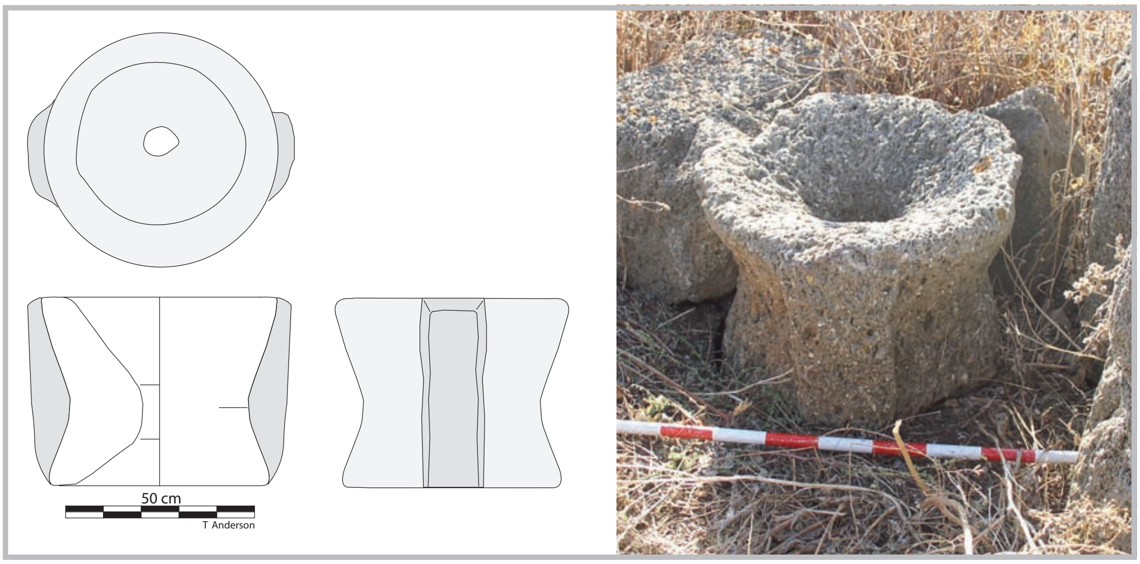


Fig. 11.17: Unfinished Pompeian upper stone scored from biocalcarenite. This is another example of the Roman exploitation of this type of rock (drawing by T. Anderson).

Roman limestone tufa (travertine) millstone quarries: Limestone tufa workings at Almedinilla, Córdoba (CO-15), known since the Iron Age, did not die out after the Roman conquest. These unidentified extraction sites pursued production during Roman times, as seen by a few querns at the Museum of Almedinilla (fig. 11.18). One upper stone presents identical grain receptacles and radial slot cuttings as those of Roman volcanic models in the Cabo de Gata. A second, with a rectangular lateral handle hole and rynd cuttings on its upper surface, betrays another Roman tradition. Limestone tufa or travertine therefore continued, at least on a small scale, to be made in Roman times.

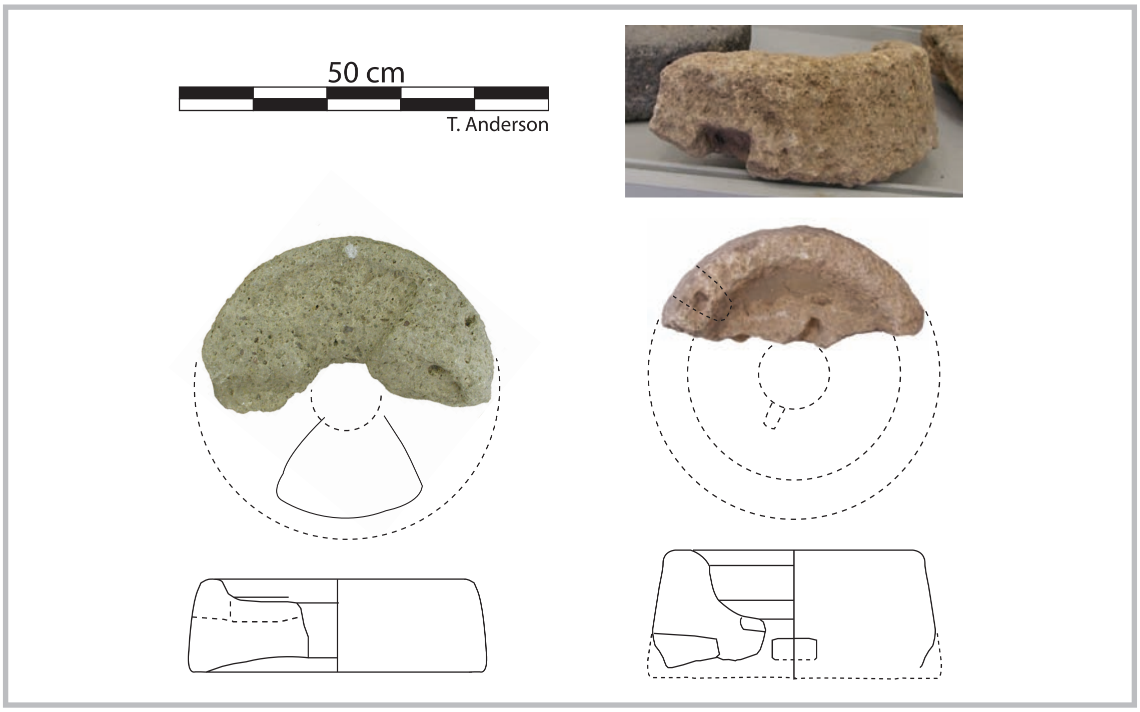


Fig. 11.18: Examples of Roman limestone tufa querns in the Museum of Almedinilla (by T. Anderson).

Roman calcareous sandstone millstone quarries: To conclude the sector on the means of dating the different Roman quarries, we mention two other sites that are not confirmed in the field. The first is inferred from a single, unfinished Roman ring-mill 60 cm in diameter noted in the article by Matilla Seiquer on the Contemporary oil roller quarry of Fortuna (MU- 4), Murcia. This solitary example appears to be a sandstone or fine conglomerate and could correspond, like the Contemporary oil rollers, to an exploitation of surface blocks. An identical fine conglomerate example, from Roman context, is stored in the depository of the Museum of Murcia (no. 31, Anderson *et al*. 2011: 16).

The second quarry is inferred from a yellow sandstone quern fragment recycled as construction material in the wall of the Roman villa of El Tesorrillo, Granada (excavated by I. Rodríguez). This piece, securely dated to Roman times, probably proceeded, as did the saddle querns from the Prehistoric sites of Los Pensadores and Las Rajas (see Prehistoric quarries), from the nearby outcrop of Zujaira (GR-12). These examples, like the previous limestone tufa querns of Almedinilla, point to local Roman quern productions that were an alternative to the volcanic imports.

Roman granite millstone quarries: For logistical reasons, we have spent little time in the granite production districts to the north of the Guadalquivir River Basin and have not identified any Roman millstone exploitation in the field. All the same, there is sufficient evidence from examples stored in museum collections or mentioned in publications, to determine that granite, because of its hardness and accessibility (in the form of surface boulders or bedrock outcrops), was exploited on a large scale in Roman times.

Production centres around Mérida (BA-6) must have abounded, as seen by the granite querns and ring mills in the depository of the Museo Nacional de Arte Romano in Mérida at the *lapidarium* of the Alcazaba of Mérida. Of the more than 100 millstones recorded in the files of the museum, it appears that a large proportion is granite. Because of storage conditions, unfortunately, we only had limited access to the collection.

All said, the basic construction material of Roman Mérida was granite as seen by its most imposing monuments. An important source was the huge "pit" quarry, a few kilometres from the city, that later became the Proserpina Dam. Granite for the Temple of Diana is reported to have come from the nearby sites of Cuarto de la Charca, El Hinojal and Royanejos (Álvarez Martínez 1991: 86). Any of these Roman exploitations could have also supplied millstones.

The granite districts of Gerena (SE-7) and Piedras Molares (CO-11) by Villanueva de Córdoba present similar situations. Each of these districts shares a long tradition of granite production and stores in its museums what appear to be both Roman and Medieval rotary querns.

11.3.2.4. Undated quern quarries

The quarries of the Barranco de los Molinos at Ibi (A-2) in Alicante and Villar de Plasencia 2 (CC-2) in Cáceres, sites we have not been able to visit personally, are awkward to date. These two true extractive quarries, with their small, relatively thick extractions (fig. 11.19), could potentially date from the Late Iron Age to Roman times. A later Medieval date can probably be dismissed due to the low diameter/thickness proportion. The search for dating indicators for these sites (identical querns in local museums or nearby settlements) is a project for the future.

Fig. 11.19: Example of a small unfinished quern extraction at Ibi (A-2). The quern is difficult to date. The proportion of its diameter to its width suggests a Roman or Iron Age date (photograph by Ágata Marquiegui).

11.3.2.5. Middle Age quern and millstone quarries

The dating of quern and millstone quarries to the Middle Ages, a span of about a millennium, is particularly delicate. The problem is the practical absence of written sources and other chronological indicators, as well as the scarcity of securely excavated archaeological complexes and published millstone assemblages. It is, even so, becoming obvious that the Middle Ages inherited from Roman times a large array of mills, from domestic querns to industrial watermills, and this variety seems to be reflected in the wide array of extractions of varying morphometrics and petrography. Since the intrinsic characteristics of these quarries are still poorly defined, they can be dated in part by means of their differences with Roman quarries.

Hence, non-volcanic, flat, discoidal querns measuring about 50 cm in diameter, can be considered Medieval. No other typological factors come into play because these quarries, on the whole, have left nothing behind but extraction hollows. To complicate their chronology, most of these sites (except Zagra, GR-5) are not characterised by extractions of varying size, as seen previously at the sites of Rambla Honda (AL-3) and Puerto de la Cadena (MU-1).

As to published references of this period, the study by E. Motos of the archaeological material finds of the settlement of El Cerro de Castillón in Montefrío (Granada), includes a dozen drawings of querns dated to between the 7th and the 12th centuries (Motos Guirao 1988: 465-467, 473-474, 479-480, PL. I-IV). We have recently had access to this lot and can note a dominance of limestones and sandstones - the absence of volcanic material stands out. Another reference is that of two querns from the Cabezo del Moro settlement, published in a study of the Medieval sites in the province of Murcia (Gutiérrez Lloret 1996: 205-207). Notions about the dating of these medieval querns are also gleaned from a few examples in museum exhibits and depositories (notably the Museums of Siyâsa and Murcia). Yet, these references only serve to date the rotary hand-querns. To our knowledge, there are no Medieval archaeological studies that describe or define the larger extractions, that is, discoidal millstones above 60 cm in diameter destined to animal or watermills. In this subject, we navigate blindly in uncharted waters.

Outside our direct study area, the research of J. Sánchez on the Balearic Island of Menorca has brought to light a number of quern quarries with extraction hollows reportedly dating from the 10th to 13th centuries (Sánchez Navarro 2011). Another interesting reference illustrating a few querns from the end of the 9th to the middle of the 10th century is an article about a shipwreck off the coast of France. The pottery at this site, as well as the querns, possibly originate in our study area at Pechina (Almería) (Joncheray & Sénac 1995: 30-32). S. Longepierre, in his recent thesis, has illustrated a series of querns, similar to those we observed in southern Spain dated from the 7th to the 9th centuries. Although discoidal, these examples bear different driving fittings (Longepierre 2011: fig. 358-361). Even as far as Stavanger, Norway, querns of this period are thin with flat working surfaces (Dahlin & Anderson, in press).

Thus, to recapitulate, the main indicators of Middle Age quarries are morphometric, that is, the presence of quern extractions of 50 cm and/or the presence of millstone extractions between 70 and 90 cm in diameter. The other indicators are negative: absence of written and oral sources, absence of place names and absence of volcanic rocks.

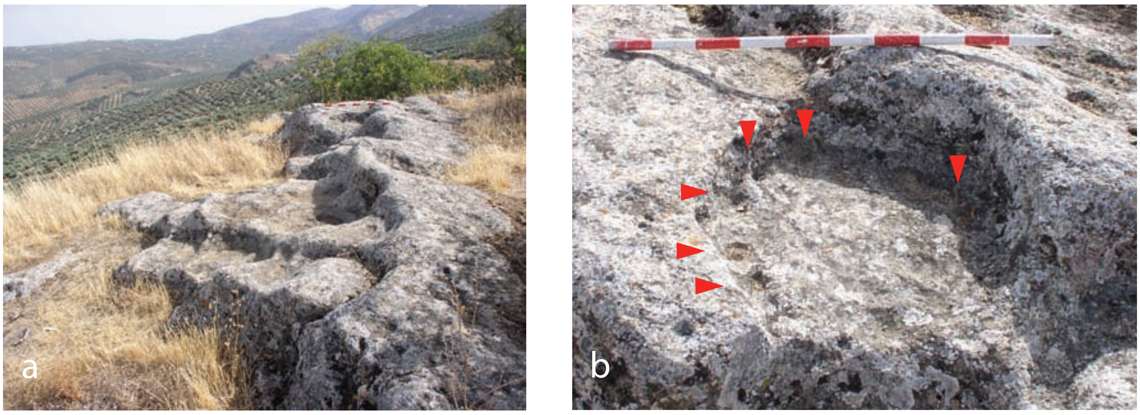


Fig. 11.20: View of the quern quarries of Zagra (GR-5) dated to the Middle Ages discoidal querns about 50 cm in diameter. On the picture to the right, one can perceive (with difficulty) the splitting marks.

The coarse sandstone exploitation of Zagra (GR-5), a homogenous true extractive quarry, is dated to the Middle Ages, in part, by the dimensions of its numerous extraction hollows corresponding to flat, discoidal cylinders about 50 cm in diameter (fig. 11.20a). This dating seems to be corroborated by a surface survey of the neighbouring cemetery, a feature just steps away from the quarry. According to their morphology, the rock-cut burial chambers date to the 6th or 7th-century (end of Visigothic domination) (Jiménez 2002: 226). It is difficult to conceive that both features, one dedicated to the realm of the sacred and the other a workshop, saw use simultaneously. A few potsherds collected on the surface in the area point to the 10th to the beginning of the 12th century (Jiménez 2002: 226). Since the date of the pottery does not concur with that of the cemetery, it is plausible that it was related to the quarry, placing it in the time of Islamic rule. Besides the quern production, a single, aborted millstone measuring 1,20 m, toward the periphery of the site, reveals that it was also frequented briefly at a later stage (Medieval to Contemporary). Production of larger millstones, however, never progressed at this site.

Another detail related to chronology of this site are the splitting tool marks. Most of these, due to long exposure, are no longer visible. Yet, in a few cases, we can perceive regularly spaced marks or indentions along the periphery of the cylinder that could be chisel carvings, either for direct splitting or holes for small iron wedges or pegs (fig. 11.20b). In any case, these marks recall the techniques identified by J. Sánchez at the sites dating to the Islamic period on the Island of Menorca (Sánchez Navarro 2011). This remains, nonetheless, a tentative indicator because there is still much work to be done on establishing a classification of the different tool marks from both Roman and Medieval times.

The conglomerate exploitation along the Calzadilla riverbed of Almadén de la Plata (SE-1a/b) is another example of a Medieval quern quarry. The discoidal quern extractions 50 cm in diameter are identical to those of Zagra (GR-5) (fig. 11:21a). The splitting technique, particularly well preserved, is also analogous to that of Zagra. Furthermore, the lower sectors of the site (SE-1b), along the Calzadilla riverbed, also show a number of extractions measuring 80 cm in diameter (fig. 11:21b). These larger extractions, most likely contemporary to the quern hollows, were probably destined to Medieval animal- or water-driven mills.

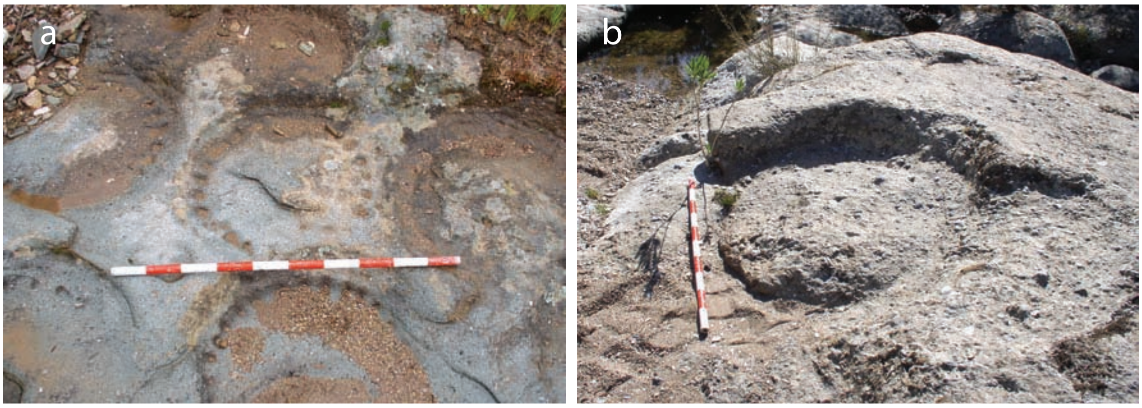


Fig. 11.21: Details of the quarry of Almadén de la Plata (SE-1a/b). a) Discoidal extractions corresponding to querns measuring 50 cm in diameter with well conserved chisel or small wedge or peg holes. b) Larger extractions measuring 80 cm in diameter for animal- or water-driven mills.

Two other small quern extraction sites, La Merced 1 (GR-4a) and El Pedroso (SE-2), are also dated broadly to the Middle Ages. The dating of the first, with discoidal extractions at 50 cm, seems relatively secure based on morphometric indicators. The extractions of the second are smaller, around 40 cm. These appear, nonetheless, too thin to be older than the Middle Ages.

Rambla Honda (AL-3a) and Puerto de la Cadena (MU-1), two large sites exploiting a "puddingstone" conglomerate with large rounded clasts, produced a number of different millstones, from quern extractions measuring from to 40 to 50 cm, to "medium-sized" extractions between 70 and 90 cm and larger models over 1,00 m in diameter (up to 1,40 m).

The quern extractions correspond to low, discoidal querns that do not appear Roman. The medium-sized extractions are also low and discoidal and cannot be mistaken for the thicker "drums" destined for Roman cylindrical mills (fig. 11.22). The larger millstones could date the Middle Ages to Contemporary times. But as we have noted previously, the Puerto de la Cadena (MU-1) shows a quern extraction that cuts into the heart of an unfinished millstone twice its size (fig. 11.23). This detail reveals that querns were being produced simultaneously or after large millstones. Based on this stratigraphical indicator, the presence of extractions of the 70 to 80 cm range and the absence of a *mola*-based place name, these sites are dated, by default, to the Middle Ages.

To this group we also add the quarry of Los Leonardos (AL-3) and the subterranean quarry of La Merced 2 (GR-4b). Although devoid of querns workings, each reveals "medium-sized" extractions, as well as later undated workings.

The quarry of Montesa, La Mola (V-2) is interesting from the chronological standpoint. Its place name suggests a date after the Reconquest, an event, in this region, that took place at the beginning of the 13th century. The upper layers of the extraction tubes of one of its oriental sectors appear to be cut (according to J. García Cerdá) by the foundations of a fortification perched on the top of the hill. This would indicate that the fortification was built after the

Fig. 11.22: Examples of medium-sized of the unfinished extractions of 70 and 80 cm in diameter at the Puerto de la Cadena (MU-1). This model does not correspond to earlier Roman ring-mills and must date to the Middle Ages.

Fig. 11.23: Rare example of a quern extraction in the heart of an abandoned millstone extraction at the quarry of Puerto de la Cadena (MU-1). This feature demonstrates their relative chronology and establishes that querns were produced consecutively or after millstones, suggesting a dating in the Middle Ages (from : http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/).

abandonment of this sector of the quarry (fig. 11.24), probably toward the 14th century during the re-population of the region (Guichard 2001: 248). In any case, we doubt, for reasons of stability of the fortification, that extraction would have been permitted along this quarry face if its foundations had been already in place. This stratigraphical relation, would then place millstone extraction presumably before the 14th century. The site merits a detailed study that would certainly provide surprises, possibly indicating that at least some of the querns and medium-sized millstones, in spite of the *mola*-based place name, took place during Islamic rule. The extractions, surpassing a metre in diameter could be more recent, dating from the Late Medieval or Modern period, and could explain the place name.

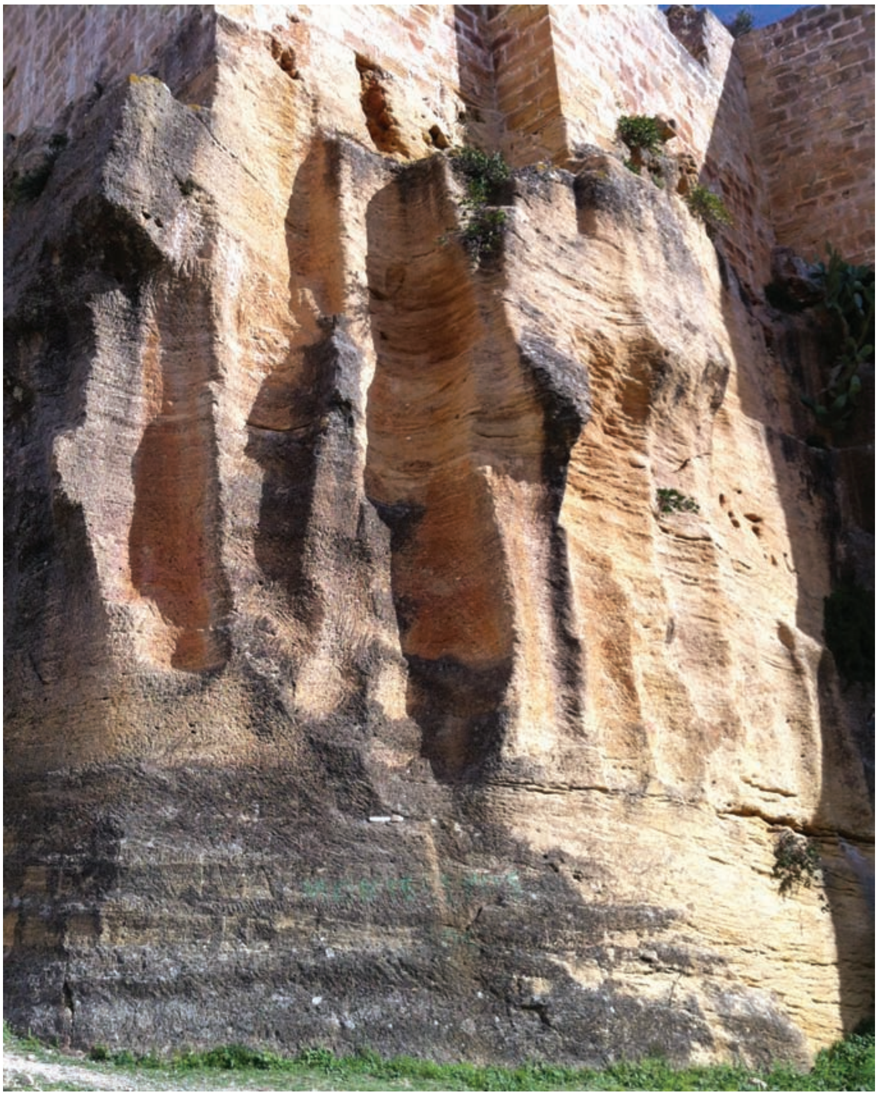


Fig. 11.24: View of a tubular face at the quarry of Montesa (V-2). The upper extractions are at the base of the foundations of the fortification. It appears that the tubular extractions are disturbed, and therefore antedate the construction of the castle, placing the quarry probably under Islamic rule (photograph by J. García Cerdá,).

Another quarry in our study area presenting quern extractions is the Playa de Carchuna (GR-9) (fig. 11. 25). At this modest site there are three small quern hollows (c. 40 cm in diameter) alongside a dozen millstones 1,50 m in diameter. Although the diameter corresponds with that of Roman quern extractions, the rock, a conglomerate with large rounded clasts, is not known to have been used in Roman times. This, once again, points to a Medieval dating. This would be a rare example of a post-Roman site extracting small querns, usually the size of Iron Age or Roman querns. The larger extractions, some of the largest in our study area, are Medieval or later.

The granite quarry of Los Molares (HU-8), near Almonaster la Real, according to its description, has extractions ranging from 27 cm to 1,30 m. The larger extractions are compatible with a Medieval or later exploitation. The problem of the smaller extractions is that 27 cm is not typical of rotary querns. This measurement deserves revision.

Several sites dated from the early 19th century in the dictionary of Madoz, present, along with their large extractions, a small number of querns extractions. Cerro el Chispas (AL-8) has a couple of small extraction hollows corresponding to conglomerate querns about 40 cm in diameter. Castillo de Locubín (J-1) has one quern blank measuring 50 cm in diameter. Each of these indicators could point to earlier Medieval phases. At Moclín (GR-1a) a phase or phases of work from the Middle Ages seems apparent by not only a few small quern extractions, but a number of medium-sized hollows tantamount to millstones of 80 cm.

To sum up the chronology of the first assemblage of millstone quarries, we turn to the site of El Patriarca (CO-12), on the outskirts of the city of Córdoba, a city celebrated for its watermills. The site comprises millstones from 90 cm to 1,45 in diameter. The authors of a recent article propose a date from either Roman or Medieval times (Altamirano & Antón 2012: 339). The sizes of these discoidal millstones, however, do not concur with Roman models. They do seem to fit the Medieval model, in particular, the smaller examples. It is interesting to note that in spite of its proximity to the city of Córdoba, it is not mentioned among the several quarries identified in the historical archives published by the medievalist Córdoba de la Llave. This absence could also be an indication that the Patriarca site precedes the Christian Reconquest.

Fig. 11.25: View of a quern extraction measuring 40 cm in diameter at the coastal quarry of Carchuna (GR-9). The size of the extraction coincides with that of Roman times. The rock type, a sort of conglomerate pudding-stone, is characteristic of the Middle Ages.

11.3.3. Chronological assemblages 2a and 2b: dating by written sources

11.3.3.1. Assemblage 2a: Production from 1481 to 1794 (table 11.3a)

This list comprises 25 millstone quarries with early working phases certified by written sources from the end of the 15th to the late 18th century. The oldest reference is a historical archive from 1481, regarding the Hornachuelos (CO-13) quarry. The last is a treatise from 1794, mentioning Fuente de Aliseda (HU-7). The letters preceding each group refer to the letters in the first column of table 11.3a.

a) The millstone quarries from 1481-1509

This assemblage begins with seven sites dated in historical archives from 1481-1509, from the transition of the Late Medieval to Modern times. The three from the Province of Córdoba, as well as that of Villagordo (J-8), are related to watermills in Córdoba. These sources are the fruits of the research undertaken by the medievalist R. Córdoba de la Llave. There is no evidence that production continued at any of these four sites beyond the indicated date. At the last three sites (El Torcal, Loja and El Berrueco), however, there is written evidence that they were exploited well into the 18th and 19th centuries. It is even not unreasonable to assume that production continued uninterrupted at these sites since the 16th-century.

b) The millstone quarries from 1557 to 1606

The next group comprises six sites from Modern times dated in historical archives from 1557 to 1606. All of them, with the exception of Montarrón (GU-8), show signs of workings in the 18th and 19th centuries.

c) The millstone quarries from 1750-1754

The site of Fuentealbilla (AB-1), recorded in the Survey of the Marqués de Ensenada (1750-1754), stands out due to its activity from end of Modern times through the middle of the 18th century. A second site alluded to in the Ensenada Survey, is that of Berrueco (CA-8), already known for its production since 1509. This site must have also known a long exploitation because it is even cited a century later by Madoz.

d) The millstone quarries of the Modern period (1481-1794)

This group comprises 14 quarries dating to the end of the Modern and beginning of the Contemporary period. Three are known to have had earlier working phases: El Torcal (MA-2), El Berrueco (CA-8) and Llerena BA-2). About half are recorded in official surveys. The Pila de Cásares (CA-9), described in detail by Martínez y Delgado, the priest of Medina Sidonia, is probably the first, along with that of El Berrueco (CA-8), to be mentioned in a text that was not a notarial archive, municipal ordinance or survey response. The exact date of the quarry is not known because the text was only published in 1875, about a century after the death of the priest. In any case, this marks the advent of a new means of recording millstone quarries: the geographical or historical treatise or dictionary.

Table 11.3a: Chronological assemblage 2a corresponding sites from written sources published between 1481 and 1794, broadly from the Middle Ages to the end of the Modern period. About a third reveal subsequent working phases identified by later written sources.

	Code	Site	Surveyed	Middle Ages	Modern (1500, 1600, 1700)	Contemporary (1800, 1900)
a	CO-13	Hornachuelos	no			
a	CO-14	Montoro	no			
a	CO-7	Albaida	no			
a	J-8	Villagordo	no			
a	MA-1	El Torcal	yes			
a	GR-2/3	Loja	yes			
a	CA-8	EL Berrueco, Cádiz	yes			
b	CO-6	Monte Izcar	no			
b	BA-2	Llerena	no			
b	M-3	Colmenar Viejo	no			
b	GU-8	Montarrón	no			
b	TO-2	Ventas Peña Aguilera	no			
b	CO-10	Albardado	no			
c	AB-1	Fuentealbilla	no			
d	MA-7	Sierra Utrera Karst	no			
d	GR-13	Otívar	no			
d	CA-9	Pila de Casares	yes			
d	TO-1	Torrecilla de la Jara	no			
d	M-2	Colmenar de Oreja	no			
d	MA-3	Alhaurín el Grande	no			
d	MA-4	Coín, Sierra Gorda	no			
d	MA-7	Jabonero	no			
d	BA-3	Llera	no			
d	BA-1	Alconera	no			
d	HU-7	Fuente de la Aliseda	no			

11.3.3.2. Assemblage 2b: the quarries of the Contemporary period (Table 11.3b)

This assemblage, the extension of assemblage 2a, comprises a total of 49 millstone quarries. On the table there are 37. The others are sites that have earlier phases of production and appear in assemblages 1 or 2a. The letters preceding each group refer to the letters in the first column of table 11.3b.

e) The Miñano millstone quarries (1826-1829)

Miñano notes production at this time at Chapinería (M-4), Pinilla de Jadraque (GU-2) and Villar de Plasencia 1 (CC-1). Two other sites recorded in his dictionary are Castillo de Locubín (J-1) and Ventas con Peña Aguilera (TO-2) that have earlier working phases and appear respectively in assemblages 1 and 2a.

Table 11.3b: Chronological assemblage 2b. This table corresponds to millstone quarries cited in publications from 1826 to the early 20th century. The list begins with three sites mentioned by (e) Miñano (1826-1829). Most sites are recorded by (g) Madoz (1845-1850) The last five sites (i) in the 20th century are identified by oral sources.

	Code	Site	Surveyed	Middle Ages	Modern (1500, 1600, 1700)	Contemporary (1800, 1900)
e	M-4	Chapinería	no			
e	GU-2	Pinilla de Jadraque	no			
e	CC-1	Villars de Plasencia 1	no			
f	BA-4	Salvaleón	no			
f	GU-1	Brihuega	no			
f	MA-2	Teba	yes			
g	CC-4	Bohonal de Ibor	no			
g	CA-10	Peña Harpada	yes			
g	SE-3	El Hacho	yes			
g	GR-6	Alhama de Granada	yes			
g	GR-10	Véñez de Benaudalla	yes			
g	GR-11	Caniles	yes			
g	HU-6	Zalamea la Real	no			
g	CC-6	Logrosán	no			
g	CR-3	Chillón	no			
g	SE-5	Alanís	no			
g	CO-9	Los Arenales	no			
g	J-7	Linares District	no			
g	AL-9	Vera	no			
g	J-5	Andújar, Los Morales	no			
g	J-6	Andújar, El Pedroso	no			
g	J-3	Huelma-Solera	no			
g	CO-16	Minas de Espiel District	no			
g	CO-17	Fuente Obejuna Jud. Dist.	no			
g	SE-6	Villanueva de San Juan	no			
g	GU-6	Corduente	no			
g	GU-7	Castilnuevo	no			
g	B-5	Jerez de los Caballeros	no			
g	MA-6	Alozaina	no			
g	MA-5	Guaro	no			
h	CO-1	Cabra, Los Frailes	yes			
h	GU-5	Tobes	no			
i	CA-12	Benaocaz	no			
i	CA-4	Playa Aguadulce	yes			
i	CA-5	Roa Martín	yes			
i	CA-13	Guadalquitón	no			
i	HU-5	Cerro del Águila	no			

f) The millstone quarries of sources of 1833

Salvaléon (BA-4), Brihuega (GU-1) and Teba (MA-2) are sites that date from three different sources published in 1833. These sites mark the transition from the list of Miñano and the large number identified by Madoz.

g) The Madoz millstone quarries 1845-1850

This assemblage comprises the 24 sites city by Madoz. To this are added three Madoz sites that appear in assemblage 1 because of the presence of hand-quern or small millstone extractions (Cerro Chispas AL-8, Castillo de Locubín and Moclín), and five sites (Loja, GR-2/3; Berrueco, CA-8; Colmenar Viejo, M-3; Colmenar de Oreja M-2; Alhaurin el Grande MA-3) with older phases of work that appear on the previous table (cf. table 11.3a).

h) The millstone quarries of the late 19th and early 20th centuries

Los Frailes by Cabra (CO-1) and Tobes (GU- 5) are the only two sites from the late 19th - early 20th century. Neither is mentioned previously by Madoz. In the case of Cabra this is surprising due to its vast workings.

i) The millstone quarries of the 20th centuries

These quarries are identified orally by people or descendants of people that personally witnessed millstone production. To this list we add Moclín that appears in previous assemblages.

These last quarries that coincide with the arrival of the French millstones that mark the end of the long tradition of millstone production in the south of the Iberian Peninsula.

11.3.4. Assemblage 3: The undated sites (table 11.4)

This last assemblage records the approximate dating of 37 millstone quarries, identified for the most part in hiking itineraries or historical websites on the internet. None, to our knowledge, benefit from written sources, and none, at least those that we have been able to survey in the field, reveal small extractions that signal older phases of work. We gather from the photographs and brief descriptions that their extractions are over 1,00 m in diameter, and therefore fall broadly into the long chronological span between the Middle Ages and Contemporary times. In this table, as in the case of the first, we are constrained to use columns representing broad chronological units. The chronological haziness of these sites will only we cleared up by future research.

Table 11.4: Chronological assemblage 3. List of 37 sites that cannot be dated precisely. From the size of their extractions, over 1,00 m in diameter, they could date from the Middle Ages to Contemporary period. At the sites we have surveyed (in grey), there is no indication of pre-Medieval workings.

Code	Site	Surveyed	Neolithic Chalcolithic Bronze Age	Late Iron Age	Roman	Middle Ages	Modern	Contemporary
GR-8	Guajar Faragüit	yes						
GR-7	Padul, Los Guillares	yes						
GR-4c	La Merced 3	yes						
J-2	El Lachar	yes						
CA-6	Chipiona	yes						
CO-3	Carcabuey, Cudillas	yes						
CR-5	Granátula de Calatrava	yes						
CO-2	Cabra, Cortaores	yes						
AL-4	Guardias Viejas	yes						
GR-14	Ugíjar	no						
AL-5	Barranco Baena	no						
AL-6	Barranco Palancón	no						
AL-7	Los Loberos	no						
HU-2	El Prao de Abad	no						
HU-3	Las Malenas	no						
HU-4	La Obra Pía	no						
HU-1	El Campillo	no						
J-4	Cambil, Arbuniel	no						
CA-11	Salto de la Mora	no						
CO-4	Vega de los Molares	no						
CO-5	Baena, Molino de la Piedra	no						
CS-3	Borriol	no						
CS-2	Lucena del Cid	no						
MU-3	Cantera de los Porches	no						
CR-4	Pedrizas de Piédrola	no						
CC-5	Guijo de Galisteo	no						
CC-1	Plasencia	no						
CS -1	Soneja	no						
GU-3	Ruguilla, Cifuentes	no						
GU-4	Sigüenza, La Cuerda	no						
GU-9	Cobeta	no						
CU-1	Portilla, Los Molares	no						
V-1	Canals, Les Moles	no						
A-1	Sierra del Molar	no						
M-1	El Berrueco, Madrid	no						
M-5	Miraflores de la Sierra	no						

11.4. Millstone quarry longevity

As we have continually stressed throughout this work, production at certain millstone quarries endured for a very long time, even centuries. The Montjuïc by Barcelona was probably exploited continuously, as recorded in a number of documents, from as early as the 13th century (Gutiérrez 2009: 91) to the 20th century as seen in a series of photographs. Among the millstone quarries of the south of Spain, there are indications suggesting any production comparable to that of the Montjuïc. There are nonetheless indicators of longevity spanning several centuries, in some cases doubtlessly continuously. These, therefore, from the evidence we have been able to gather, can be considered the most important millstone production centres of southern Spain.

Two of the three reputed prehistoric saddle quern quarries, Zujaira (GR-12) and Cabezo de Olivo (MU-2), for example, seem to have been producing rotary querns centuries later in Roman times. There is no evidence, however, of a continuity of production at these sites. It may have been a coincidence or it may have been that millstone makers of different times knew how to recognise a good rock.

Concerning Roman production, there is evidence that certain rocks in volcanic and granite districts were exploited over a long period of time. The quarry beside the Roman city of Sisapo (CR-1), with its more varied production, could have lasted for several centuries. Specific sites, such as Cerro de Limones (AL-2) and Hoya del Paraíso (AL-2), due to the fact that they only produced one type of quern, a standardised product, were probably not worked for more than a generation.

The long working life of Moclín (GR-1a) cannot be evidenced by written sources (its only citing comes from Madoz, 1845-1850, or later), but from the number and variety of its extractions, including hand-querns and small and large millstones, we can suppose it was active for centuries. Once again, the massive quantity of rock available, and the site's proximity to a town where the workers were housed (and possibly took part in other activities), favoured its longevity and continuity. A similar situation would be expected at the sites of Alconera (BA-1), Montesa (V-2) and Rota (CA-3).

The large medieval production of Puerto de la Cadena (MU-1), with its mixture of querns and millstones, probably certainly endured a long time. All the same, it is not possible to determine if its production was continuous or not. Continuity does not appear to be the case for Carchuna (GR-9) and Cerro El Chispas (AL-8), sites with both quern and millstone workings, because the total quantity of extractions is very low.

By means of written sources, we can assume a continuous production at a number of sites for a range of three and four centuries (fig. 11.26). Continuous work at El Berrueco (CA-8) for at least four centuries is certified by records from 1509, 1750, c. 1775, 1813 and 1846 (see catalogue for sources). This is perfectly compatible with its enormous rock mass (now a giant crater) and complex infrastructure (notably dwellings). Although there is no evidence, it cannot be excluded that production preceeded the 16th century. It is unfortunate that the old millstone workings have been destroyed by the more recent work.

In the case of Loja (GR-2/3), the evidence of continuous work through four centuries is less certain and corroborated by only two sources (1502 and 1847). This extensive source of rock near a city with many watermills would, nonetheless, have favoured continuity of production.

Continuous exploitation for at least three centuries seems apparent at the Ventas con Peña Aguilera (TO-2) due to four different written records (1576, 1587, 1821 and 1828). Furthermore, in the 16th century, Ventas con Peña Aguilera had the reputation (certainly inflated) of being the best millstone quarry in Spain (Viñas & Paz 1951: 216).

Other sites with evidence of continuous work over three centuries are El Torcal (MA-1) (1500 and 1789); Llerena (BA-2) (1566 and 1791); Albardado (CO-10) (1606 and 1846); and Colmenar Viejo (M-3) (1574 and 1847). In the case of Colmenar Viejo, there are postcards that illustrate a vast exploitation of construction material in the early 20th century. We ignore, however, if millstone production was active at this late date.

There were certainly other sites among those identified in this study that knew a long, continuous millstone activity. Their identification require future research, in particular in official archives.

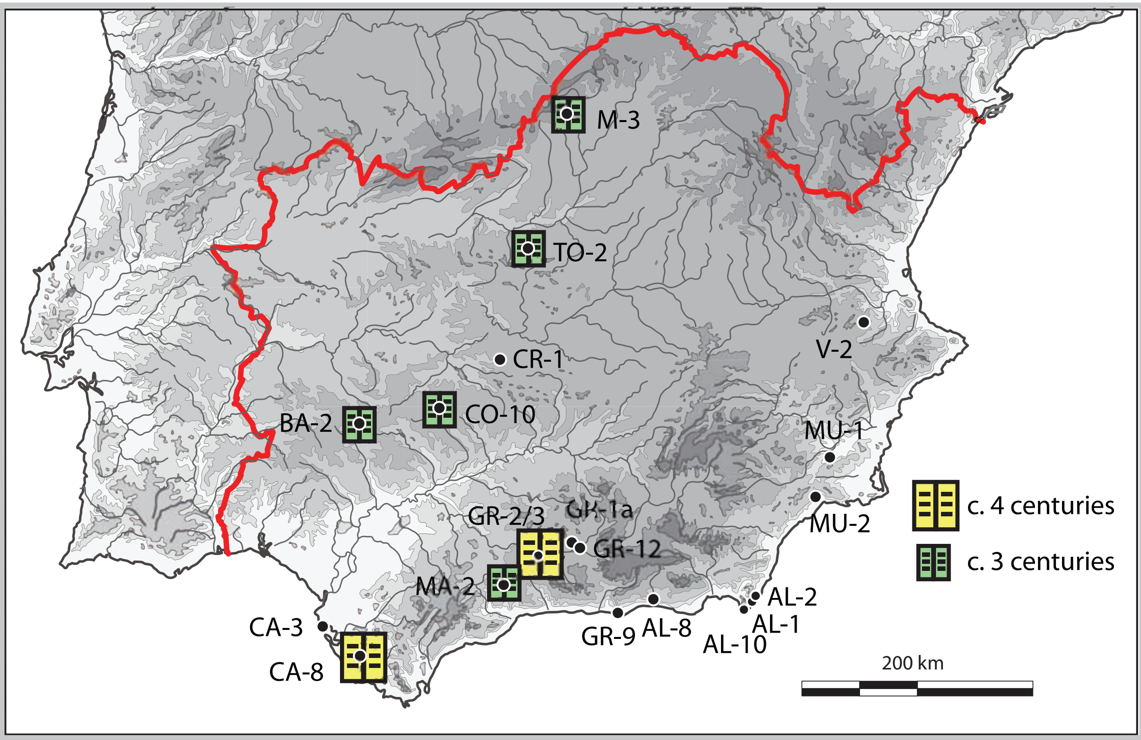


Fig. 11.26: Map of the sites mentioned in section 11.4. The symbols indicate the sites with a probable continuity of production of three to four centuries based on written sources.

12. FROM QUARRY TO MILL: MILLSTONE DISTRIBUTION

12.1. Generalities

Quern and millstone quarries, depending on their sphere of commercial distribution, are divided into three categories: local, regional and long-distance. Through time, the distances that defined the boundaries between the spheres are relative and fluctuated depending on the nature of the product, notably its size and weight, and the means and conditions of transport. It is awkward, for example, to compare the transport of a saddle quern collected in a nearby riverbed quarry with hauling a heavy millstone, 1,30 m in diameter, from an extractive quarry in an ox-driven cart over a distance of 100 km. Therefore, the definitions we propose to distinguish the categories of commercial reach of quarries, as well as the distances, must be placed in their chronological contexts and be considered as hypothetical.

The setback to this diachronic approach to millstone trade is the imbalance of evidence from the different periods. From Prehistory and Protohistory, there is very little evidence. For Antiquity, the number millstones in depositories is sufficient to establish reliable distribution maps by mill type and rock type. For the Middle Ages, the data, once again, is almost nonexistent whereas for the Modern period the evidence is very limited, in spite of a growing number of historical archives. These foreshadow the numerous of written accounts from Contemporary times.

Local quarries

Local quarries are defined as small exploitations producing a limited number of millstones. Work, undertaken by a small team, was intermittent and depended on specific needs or purchase orders. These sites supplied millstones to settlements or mills located a "short distance" from the quarry. In Prehistory and Protohistory, these sites were probably, *grosso modo,* inside the "site catchment" sphere of several kilometres, or a walking distance of a few hours. In later periods, the distance from the mill to the quarry could be greater, about 20 kms, roughly the distance that could be attained by a cart in one or two days (cf. Sainz 2007: 176-178). In earlier times, the raw material of these small sites was exploited at will, without the consent of a land owner, and left little scar on the landscape. The relationship between the client and the millstone maker at these sites was most likely direct, without the intercession of a merchant. Transport of the products was mostly undertaken by the millstone makers or the client. Although the transport could at times be complicated by difficult terrain and weather conditions, it did not entail more than one or two days. The millstone maker, although highly skilled, was not a full-time stone worker (for millstones or for construction) and took part in other activities, most likely related to agriculture.

Regional quarries

Regional quarries were larger and produced many more millstones than local quarries. In early times, they differed little from local quarries except in the quantity of their production and the reach of their trade. In more recent times they were exploited either year-round or seasonally by specialists who required the consent of the owners of the land. Sectors of these quarries were leased, often in exchange for a determined number of millstones a year. Crews of workers, usually led by a master who directed the crew (sometimes his own family), maintained contact with the owner and the client. Production followed a sustained rhythm to fill specific purchase orders of clients. These sites also had the option of accumulating a stock of millstones that could be subsequently commercialised directly to clients or by merchants. Such sites required a more complex infrastructure. In the case of permanent or seasonal presence, this implied room and board for the workmen, and at times, their families. The families also participated in the production process (removing debris, for example) and in other domestic tasks. Tool maintenance required the presence or simple access to a smithy, an activity some of the stonemasons themselves exercised. These sites supplied millstones farther away than their smaller local counterparts, over a distance of 20 and 50 km. This transport required more sophisticated logistics and, at times, the intervention of transport specialists (*arrieros*, *carreteros* or *barqueros*). Depending on the distance and the natural obstacles (mountains, rivers), this could take several days. These requirements, in addition to toll fees, raised the costs.

Long-distance quarries

Long-distance productions required all the characteristics of the regional quarry. The difference is that production was on a larger scale, requiring more workers and infrastructure and an unlimited quantity of rock. The millstones of these quarries also had to benefit from an excellent reputation, so as to draw the attention of distant clients. From the logistical standpoint, these sites required more sophisticated means of transport and a higher developed network of trade routes. This resulted in a higher cost of the product. Millstones from these sites transited, from the moment of their manufacture to their final destination, through the hands of a number of individuals. This process began with the millstone maker, continued through the merchant and the professional transporter with halts at various trading posts. In Roman times, this appears to be the case of the 130 volcanic querns in the shipwreck of Illa Pedrosa, originally from quarries around Ullastret, Girona, that were stored and redistributed from the port of Empuries, Girona, before their last journey by sea (Vivar 2004: 108). In more recent times, specialised millstone merchants, called *moleros*, made a living from commercialising these products. The degree of distribution and distances these products travelled in Contemporary times, before the huge influx of French siliceous stones from even more distant quarries, is seen in a Royal Decree of the 21st of May, 1829. The decree prohibited Marcelino Franco, a merchant of Pontevedra, Galicia, from importing Portuguese millstones due to the alternative of acquiring Spanish millstones in the Provinces of Álava (Basque Country) and Granada or other quarries of Andalusia (Ferrer 1830: 219-220). In any case, from early times, a characteristic of long-distance quarries was the large divide, sometimes measured in hundreds of kilometres, between the millstone maker and the final client.

12.2. Quern distribution in Prehistory and Early Protohistory

There are three presumed saddle quern quarries in our study area (fig. 12.1). None of the three are completely certain, and all would benefit from further fieldwork and petrographical analyses. All traces of the site of Mazarrón, Murcia (MU-2) are now probably destroyed (S. Agüera, pers. comm.). Zujaira (GR-12), a site suspected of also having produced rotary querns in Roman times, supplied querns (and other lithic material) at least to the settlements of Los Pensadores (Late Neolithic) and Las Rajas (Chalcolithic), located, respectively, 2 km and 200 m away (fig. 12.2). It is not possible to guage if this is simply a local exploitation, or if it supplied more distant settlements.

El Barronal (AL-10), identified by F. Carrión at the southeastern point of Cabo de Gata, produced volcanic saddle querns among other artefacts (Carrión 1993). Volcanic querns, either from El Barronal or another unidentified site in the Cabo de Gata district, are known at the settlement of Los Millares 50 km away (cf. fig. 12.1) (M. Ramos, pers. comm.). This is clear indication that certain volcanic rocks were circulating beyond the local sphere already in Late Prehistory. These querns served as a higher quality alternative to the more common garnet mica schists known at Los Millares that were most likely collected from surface "quarries" in riverbeds and ravines.

Our knowledge of the oldest quern quarries dating from Late Prehistory and Protohistory are too incomplete to advance a coherent view of quern distribution. More research in these chronological periods is necessary before we can establish is querns were circulating in the same manner as other types of objects, for example stone axes.

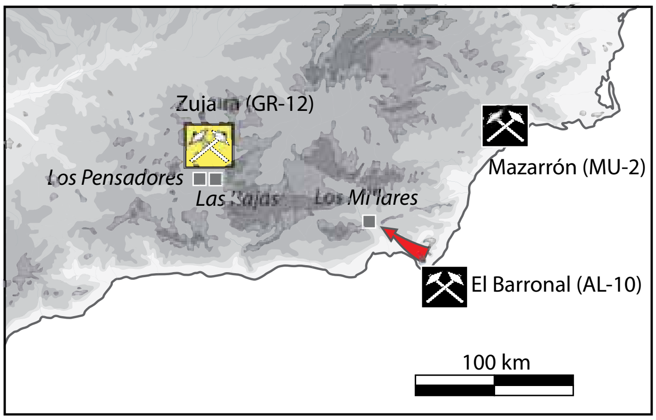


Fig. 12.1: Location of presumed Prehistoric saddle quern quarries and the settlements they supplied. El Barronal (AL-10) is reported to have supplied querns to Los Millares, about 50 km away. Zujaira (GR-12) supplied the nearby settlements of Los Pensadores and Las Rajas (see detail below).

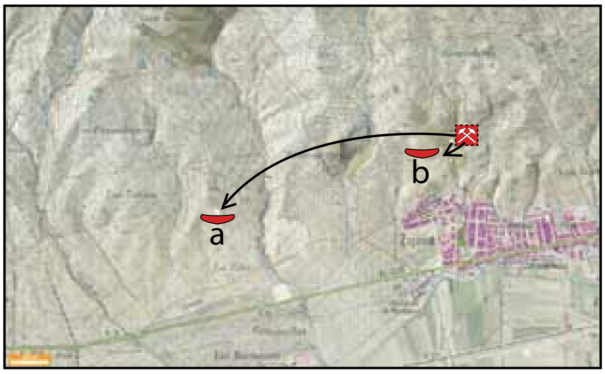


Fig. 12.2: Detail of the Zujaira quarry (GR-12) and the settlements of a) Los Pensadores at a distance of1,5 km and b) Las Rajas at 200 m.

12.3. Late Iron Age quern and millstone distribution

The question of Iron Age quern and millstone distribution in our study area was briefly presented at the recent Bergen colloquium in 2011 (Anderson *et al*. in press). Since then, we have had access to more Iron Age millstones that permit us to expand the perspective of distribution in the Late Iron Age beyond the local sphere, to include both the regional and long-distance quarries. In any event, our research for this period is still very incomplete and is for the most part focused on the southern half of our study area. We know nothing of Iron Age settlements, for example, in the vast Campo de Calatrava district in Ciudad Real or, for example, their exploitation of the numerous local and regional volcanic resources.

Most of the Iron Age millstones in our study area (fig. 12.3) are surface finds from sites interpreted as Iberian Culture *oppida*. The Zujaira pair, in a private collection, are reputed to come from the *oppidum* of *Ilurco* at the Cerro de los Infantes, Granada (fig. 12.4). The upper stone in the Museum of Alcalá la Real is, presumably, from La Mesa at the Aldea de la Ribera Alta, Jaén, also a reputed Iberian *oppidum* (C. Calvo, pers. comm.) (cf. chap. 3, fig. 3.4, c). The assemblage in the Jódar museum is from the *oppidum* at the Cerro Castillejo, Jaén (López Marcos 1995). The finds from Baza, Granada are from the *Basti* complex (A. Adroher, pers. comm.), a site known for the celebrated Dama de Baza statue brought to light from its necropolis in the 1970s. Apart from examples with unsecure contexts, there are several i*n situ* finds known at the sites of Cerro de la Cruz, Almedinilla, Córdoba (Quesada *et al*. 2010) and at the Castrejón de Capote, Higuera la Real, Badajoz (Berrocal Rángel 1989).

The well-dated assemblage from the 2nd-century BC settlement of Cerro de la Cruz is from a site that was the object of several campaigns of systematic archaeological work (Quesada *et al*. 2010). An article dedicated to this assemblage that we have been able to consult was recently submitted for publication (Kavanagh *et al*., in press). As to petrography and provenancing, most of these querns and millstones (cf. chap. 3, fig. 3.13-3.14) were scored from a highly porous limestone tufa, or "*travertino*" (Kavanagh *et al*., in press), a type of rock with outcrops known throughout southern Spain. Although no quarry has been identified in the field, lime-

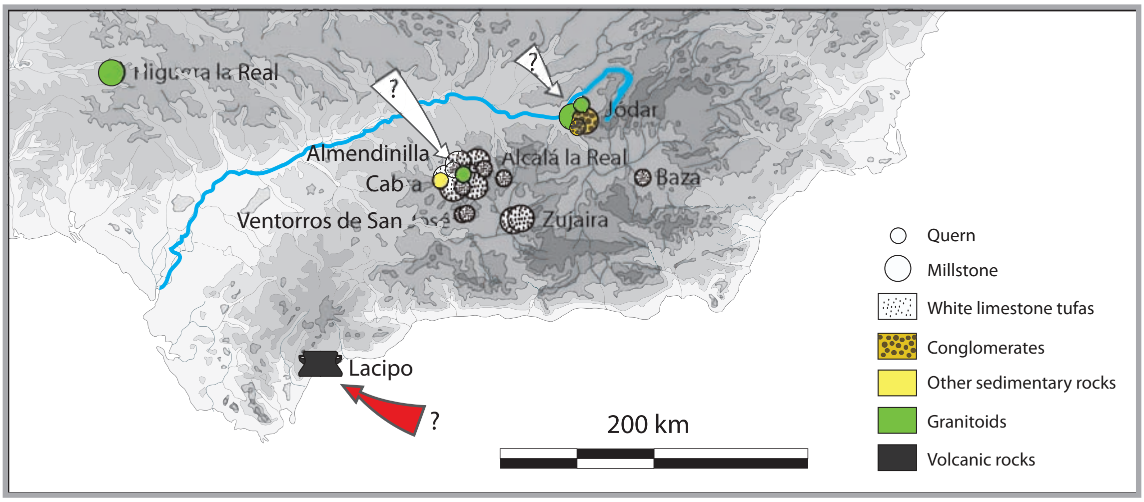


Fig. 12.3: Distribution map of querns and millstones in the Late Iron Age. There is only one reputed tufa millstone quarry in the study area at Almedinilla (CO-15), Córdoba, that supplied the local sites. The granite querns of Cerro de la Cruz and Jódar are exogenous. The closest outcrops are c. 70 and c. 40 km away (see arrows). The volcanic biconical mill of Lacipo is an example of a pre-Roman long-distance import from an unknown source elsewhere in the Mediterranean Basin.

Fig. 12.4: Limestone tufa millstone pair from a private collection in Zujaira, Pinos Puente, Granada (Ø: 57 cm). The upper stone is equipped with opposite vertical slits. The mill reputedly comes from the nearby Iberian Culture settlement of Ilurco, *at the Cerro de los Infantes.*

stone tufa is known along the riverbed of the Almedinilla River (CO-15), a short distance from the Cerro de la Cruz. The recent discovery of a Roman ashlar quarry along this river valley (Muñiz *et al.* 2012: 165) could be a clue to the location of earlier millstone exploitations.

What we cannot know is whether this potential source only supplied the local settlements or engaged in a greater production of millstones supplied to settlements farther away. A Baza upper stone of this type of rock, for example, could be an import from a distant quarry such as that suspected at Almedinilla, or hewn from a outcrop about 10 km to the north of Baza, near the Baños de Zujar (Geological map IGME, 972). The question remains open.

The conglomerate millstones of Jódar (cf. chap. 3, fig. 3.4, d) probably reflect the exploitation of local surface blocks or are from an extractive quarry. Conglomerate outcrops are common in the region.

Fig. 12.5: Quern and millstone from Jódar, Jaén. The quern to the left is a conglomerate (Ø: 40 cm); the stone to the right is a granite (Ø: 52 cm). Both have handle lugs. The lug of the quern is carved with an "inverted keyhole" fitting (photograph by Ildefonso Alcalá, Museum of Jódar).

The *in situ* mill at the pre-Roman "Celtic" hilltop *oppidum* of Castrejón de Capote is in southern Badajoz. The mill is slightly over 50 cm in diameter and is set on a podium (Berrocal Rángel 1989: 258; 284, fig. 26.1). Its rock, granite, must have come from a nearby exploitation; granite is common to the Ossa Morena and South Portuguese geological zones.

The granite querns at the Cerro de la Cruz (cf. chap. 3, fig. 3.4, e-f) and Jódar (fig. 12.5b), by contrast, are exogenous. The source of the Cerro de la Cruz model is the granite fields beyond the Guadalquivir River Basin, in the Central Iberian Zone (see chap. 4, Zone D) at least 70 km away, whereas the nearest to Jódar is around Linares (J-7), about 40 km to the northwest, a district known for millstone production in Contemporary times (Madoz 1847, Vol. 10: 290; Lozano Muñoz 1867: 17). In any case, these two querns reveal that some querns in the Iron Age, alternatives to local models, were circulating at the regional or larger scale.

The *Lacipo* volcanic upper stone (fig. 12.6), with no parallels either within or outside the Iberian Peninsula, is an example of even more distant millstone trade. This piece, stored in the Museum of Málaga, is a surface find from the ancient city of *Lacipo* (Casares, Málaga), a site with strong Punic ties dating to the 3rd or 2nd century BC (inv. A/CE 2585; J. Suárez, pers. comm.; Puertas 1982: 88, fig. 50). Its section is biconical with an upper "hopper" about half the size of the lower. The grinding surface features parallel furrows. What is particularly unique are its driving fittings. The original handles were "ribbon" shaped (fig. 12.6.1). After one of these fragile handles broke, it was replaced with (fig. 12.6.1.2) an "inverted keyhole" cutting to lodge the rynd-handle crosspiece that attached the wooden frame for assembling and driving the mill. Apparently, the combination of handle 1 and cutting 2 was not efficient so it was replaced by two smaller opposite "inverted keyhole" cuttings (fig. 12.6.1.3a-b).

The closest parallel to the Lacipo *upper stone* is the Morgantina mill, a type known in Sicily and in the shipwreck of El Sec off the coast of Mallorca as early as the 3rd (White 1963: 205) or 4th century BC (Williams & Thorpe 1990). They share similar rock types, dimensions and asymmetric hoppers. But the comparison stops there, especially regarding the driving fittings. The finer ribbon handles on the upper half of the *Lacipo* mill are far from the massive square lateral lugs on the lower half of Morgantina mills.

All said, the repairs of the handles of the *Lacipo* mill are compelling. "Inverted keyhole" cuttings, as we have noted (cf. chap. 3.3.1), are commonplace in Spain on querns and millstones of the Late Iron Age, as seen from the examples from Cerro de la Cruz (Córdoba), Jódar (Jaén), Numantia (Soria) (fig. 12.7) and Castrejón de Capote (Berrocal Rángel 1989: 284, fig. 26.1), and place this volcanic import firmly within this chronological period.

The origin of the *Lacipo* upper stone is unknown. There is no evidence of early, pre-Roman rotary mill production in either of the two volcanic districts in our study area (Campo de Calatrava and SE Spanish volcanics). This mill must therefore be a long-distance import brought by sea traders from one of a number of potential volcanic districts throughout the Mediterranean Basin. This mill is a precursor not only of the volcanic similar shaped Pompeian models that would be arriving sporadically on Iberian soil after the Roman conquest, but of a vast, indigenous, volcanic production that would be taking place on Iberian soil in subsequent years.

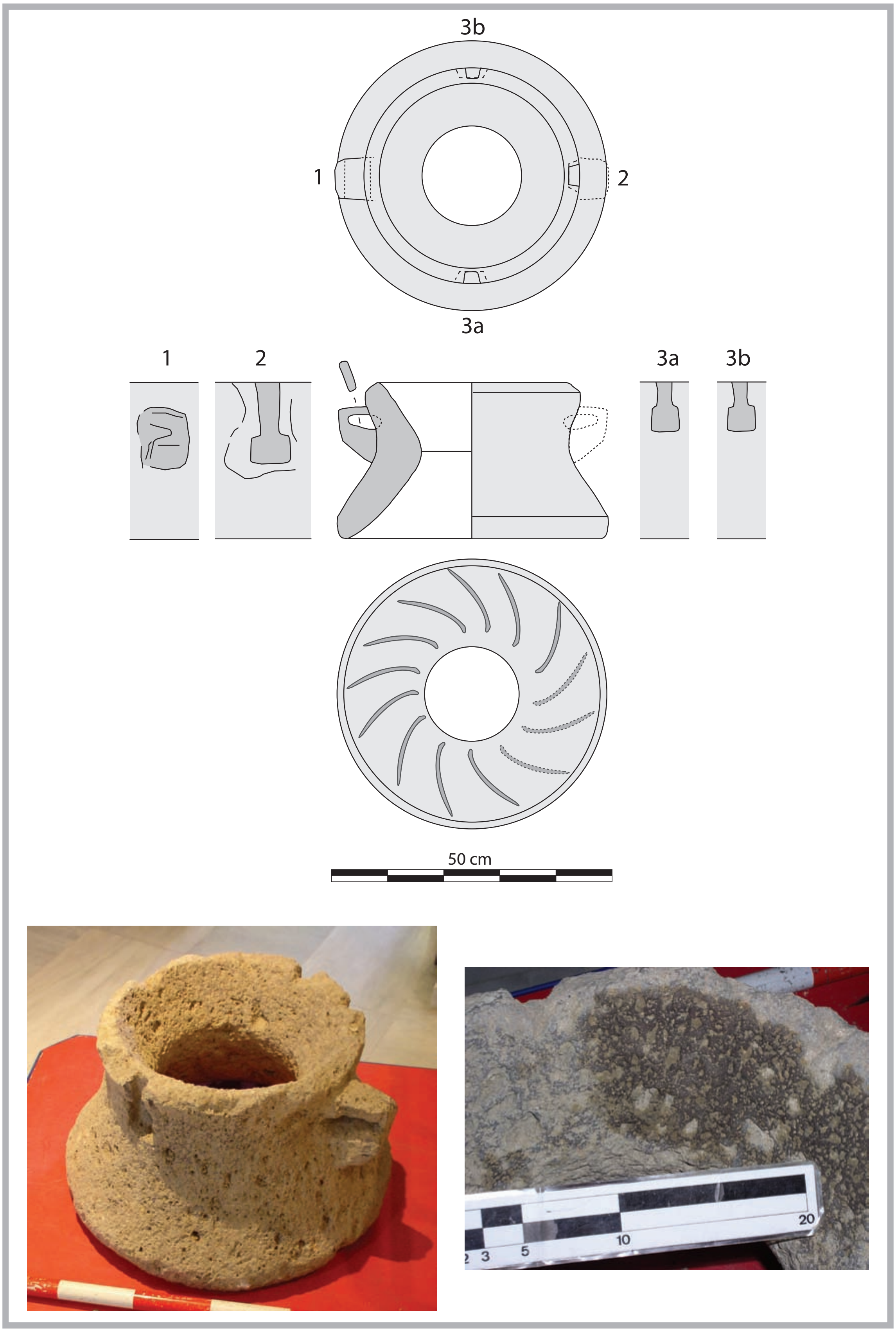


Fig. 12.6: The volcanic biconical, furrowed, upper stone is a surface find from the ancient city of Lacipo, Málaga. Its original system of 1) ribbon handles was replaced successively by 2) and 3) "inverted keyhole" cuttings, typical fittings of the Late Iron Age in the Iberian Peninsula. The dark vesicular stone is seen in the detail. The stone is a long-distance import from an unknown source (drawing by T. Anderson modified from original drawing in Puertas 1982: 88, fig. 50).

There are few Iron Age millstone procurement studies in Spain that serve as models for comparison. The large collection of conglomerate and sandstone millstones from the celebrated site of *Numantia* (Soria) (fig. 12.7) are reported to have been collected from outcrops in a radius of a few kilometres (Checa *et al.* 1999: 64). Their exact location, however, is not known. From what we have been able to observe, due to their often rounded sections, they probably were the result of knapping surface blocks. Furthermore, among the *Numantia* collection exhibited at the site, there is no evidence of granite or volcanic materials indicating longer-distance imports.

Oriental Catalonia has benefitted from a larger number of Iron Age settlement excavations (Alonso 1999, Asensio *et al.* 2001; Portillo 2006). The model of quern and millstone procurement there is analogous to that of our study area. To simplify, most are of either local or regional (Portillo 2006; 26, 459). Among the 23 examples at Alorda Park, Tarragona, dating from the middle of the 5th to the 3rd BC, there are bioclastic stones probably hail from the Mèdol quarry about 20 km away; there is, however no indication of regional or long-distance granite or basalt imports (Asensio *et a*l. 2001: 58).

The bioclastic limestone lower stone of Els Vilars (Arbeca, Lleida), dating to the middle of the 4th century BC, is also possibly from El Mèdol, about 60 km to the southeast. A volcanic lower stone at the settlement of Ca n'Olivé (Cerdanyola de Vallès, Barcelona), also from the middle of the 5th century BC and 100 km from the Olot-Garroxta volcanic district, suggests an early distribution of querns (Alonso 1999: 262, fig. 171).

Fig. 12.7: The collection of querns and millstones from celebrated settlement of Numantia, Soria. Most of these stones are sandstones or conglomerates. There is not indication of long-distance imports. Both the larger millstone (a) and the quern (b) are equipped with lateral "inverted keyhole" cuttings. Other driving fittings, however, are known at the site, such as lateral lugs with vertical holes and vertical slits (cf. Checa et al. 1999: 65, fig. 2).

A major difference of our study area to northern Catalonia is the widespread presence of volcanic mills at Iron Age sites. This is especially the case of the Indigècia region with 48% of its grinding stones hewn from basalt (Portillo 2006: 26). This high percentage is not surprising since these sites are very near the Olot-Garrotxa volcanic province in Gerona.

Summing up, most Iron Age querns appear to be local or regional production. The granites at Cerro de la Cruz and Jódar and the bioclastic limestone of Arbeca reflect regional trade at least between 40 and 70 km. They could potentially come from farther and even qualify as long-distance trade. This would not be surprising. In the La Tène Culture of Central Europe, Reddish breccia querns from Schweigmatt in the German Blackforest, for example, are known at Bern, Switzerland, about 100 km away (Joos 1975); reddish "rhyolithtuff" querns in Germany were travelling from their presumed source in the Odenwald Mountains up to 120 km along the Neckar River (Lehmkuhl 2011: 82); and a puddingstone recovered at Rowbury in southern England presumably comes from across the English channel in Normandy (Peacock & Cutler 2011: 77). This longer distance distribution appears to be, from the current evidence, more of an exception than a rule, and does in no way compare to the vast network of millstone trade that will be introduced after the Roman conquest.

12.4. Roman millstone distribution

Compared with previous periods (and to a certain extent later periods), the circulation of millstones in southern Spain reached a peak in the Roman period. An essential factor in this expansion was the massive introduction of volcanic stones from a number of quarries in the volcanic fields of Campo de Calatrava and the SE Spanish Volcanic district straddling the Provinces of Almería, Murcia and Albacete. These centres provided high-quality products over short and long distances, profiting from long-established trade routes for traditional products such as olive oil, metals, cereals and fish derivatives.

The number of Roman quarries identified (or inferred) directly in the field, as well as the number of Roman millstones in museums, permits us to draw up separate distribution maps according to mill types (fig. 12.8 and 12.9).

The first shows the distribution of rotary querns. This spread can be divided into three main zones where three different rock types prevail. The eastern sector was dominated by volcanic material. The southern sector was dominated by the shell-rich biocalcarenites with quarries known along the Atlantic coast in the Province of Cádiz. The western sector was dominated by granitoids. The southern biocalcarenite sector and western granite sector remained "faithful" to their traditional local and regional rock and seem to have "resisted" the arrival of volcanic rocks.

The second map, indicating the spread of cylindrical and Pompeian mills is less conclusive and shows that more research needs to be focused on these mill types, in particular the cylindrical model.

12.4.1. Roman hand-quern distribution

The spread of hand-querns throughout southern Spain can be divided into three sectors corresponding to three different rock types.

12.4.1.1. The eastern volcanic quern sector

The distribution of volcanic querns (cf. fig. 12.8) covers the eastern half of our study area coinciding with the two volcanic districts (SE Spanish volcanics and the Campos de Calatrava) and the areas in between. It stretches more thinly to *Emerita Augusta* (Mérida) and Carmona in the west, and as far south to *Baelo Claudia* on the Atlantic coast and Almuñecar, ancient *Sexi*, on the Mediterranean.

The Cabo de Gata quarries of Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2), in the southern sector of the SE Spanish Volcanic Province, produced hand-querns exclusively, and in large quantities. They obviously supplied the local and regional settlements in the area, as seen by examples at several settlements in the Province of Almería. The proximity of these quarries to the coastline, 4 and 2 km respectively, would have permitted them to benefit from maritime trade routes to access markets up and down the Mediterranean coastline and possibly international markets.

The lamproite productions in the northern part of the district near the coast (e.g. Mazarrón, Murcia), would have also benefitted from sea transport and the nearby important port of ancient Cartagena. In addition, as noted in a brief geological study of millstones from Baza (Molina & Cultrone 2012: 39), these millstones could have circulated by land through the Almanzora Valley, a long-established trade route connecting the coast with the interior passing through the ancient centres of Guadix and Baza (Granada) to the important trade arteries. Other farther inland volcanic outcrops, to the northwest of Murcia, such as Cancarix (Albacete) would, have benefitted from the long-standing routes connecting the coast to the inland.

The quarries of the Calatrava Volcanic district, in the heart of the Iberian Massif and far from the coast, traded their querns and millstones by means of the inland routes crisscrossing the centre of the Iberian peninsula. *Sisapo* (CR-1), Las Herrerías (CR-2) and Cerro Columba (CR-6) by *Oretum*, in Ciudad Real, are all along or near major ancient thoroughfares. This explains the distribution of volcanic querns throughout the Province of Córdoba (fig. 12.9a) and, to a certain extent, as far west as the Roman city of Mérida (Extremadura). To attain Mérida they could, although there is proof, have floated down the Guadiano River on barges. From Roman *Corduba,* they could have been ferried along the Guadalquivir river to reach Carmona (fig. 129.b), and farther down to the Atlantic coast at Cádiz.

The examples of *Baelo Claudia* and *Sexi* (ancient Almuñecar) were probably brought by sea from the quarries of Cabo de Gata or Murcia (fig. 129.c-d). Other volcanic districts in the Mediterranean, notably in North Africa or even that of Olot-Garrotxa in Gerona, Catalonia, although impossible to rule out as potential sources, are unlikely because they are not known to have produced *catilli* with radial cuttings or "*sombrero*" *metae* like those made in south-east Spain.

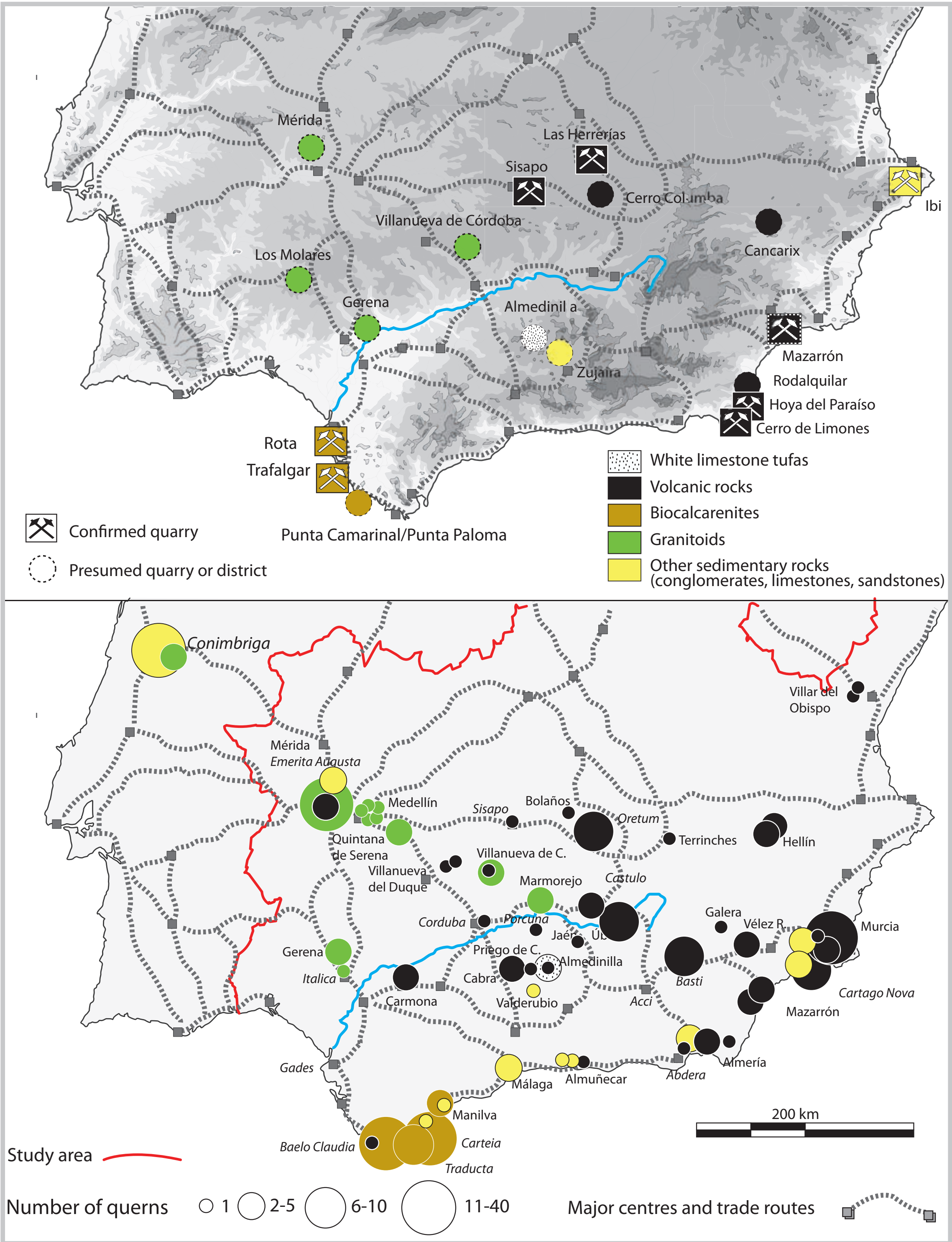


Fig. 12.8: Spread of Roman querns by rock type and quantity. The main concentration of volcanic querns is in the eastern of our study area, nearer their sources. The southern sector, along the Straits of Gibraltar, is dominated by biocalcarenites (ostionera), *whereas the western sector is dominated by granitoids(drawing by T. Anderson).Querns cited in publications:* ***Albacete****: Hellín (Jordan et al. 1984; Jordan & Matilla 1995);* ***Cádiz****: Iulia Traducta (Vargas & Bernal 2009);* ***Ciudad Real****: Terrinches (Benítez et al. 2011);* ***Córdoba****: Villanueva del Duque (Garcia 2002), Villanueva de Córdoba (Palomo & Fernández 2007);* ***Extremadura****: Medillín (Haba Quirós 1998), Quintana de Serena (Léon & Carmona 2006);* ***Jaén****: El Centenillo (Gutiérrez & Corpas 2011);* ***Málaga****: Estepona (Soto 1977, 64);* ***Murcia****: García Blánquez et al. 1990;* ***Sevilla****: Italica (Berrocal Rángel 2007: 281);****Valencia****: Villar del Arzobispo, (Pérez 2006). Museums, depositories and private collections (unpublished):* ***Almería****: Almería; Isla del Moro; Vélez Rubio;* ***Cádiz****: Baelo Claudia, Carteia;* ***Ciudad Real****: Bolaños de Calatrava; Oretum;* ***Córdoba****: Cabra; Córdoba, Almendinilla, Priego de Córdoba, Villanueva de Córdoba;* ***Extremadura****: Mérida,* ***Granada****: Almuñecar; Baza; Galera;* ***Jaén****: Linares; Porcuna; Úbeba;* ***Málaga****: Málaga; Manilva;* ***Murcia****: Murcia, Siyâsa; Cartagena Museum; ARQVA* ***Seville****: Carmona.*

There is a potential overlap of volcanic querns in the Province of Jaén at Ubéda and *Castulo*-Linares, situated about halfway between the Calatrava and the Murcia volcanics (cf. fig. 12.8). Petrographical analyses could certainly clarify their origins.

All said, volcanic quern quarries not only supplied mills to the local and regional clients, but sent them hundreds of kilometres, both by land and by water. The *Baelo Claudia* upper stone, for example, is more than about 330 km (as the crow flies) from the Cabo de Gata (Almería) and the Campo de Calatrava (Ciudad Real). This example could have easily traded hands on several occasions between the quarry and their final place of use.

The identification of a number of volcanic production centres, coupled with the identification of volcanic querns in their final place of use, as we will see below, will provide statistical evidence to quantify the concepts of local, regional and long-time quarries in Roman times.

Fig. 12.9: Examples or Roman volcanic rotary querns found in contexts far from their sources. All are catilli *bearing radial cuttings to lodge rynd-handle crosspieces. a) Priego de Córdoba; b) Carmona, Seville; c) Baelo Claudia, Cádiz; d) Almuñecar, Granada.*

12.4.1.2. The southern biocalcarenite (*ostionera*) rotary quern sector

In the southern-most area of the Iberian Peninsula, Roman mill makers exploiting the yellowish, shell-rich biocalcarenite along the Bay of Cádiz at Trafalgar (CA-1) and Rota (CA-3) supplied hand-querns to settlements along the Atlantic coast (*Baelo Claudia*) and further south near Gibratar at *Carteia* (pers. comm. Salvador Bravo) and *Iulia Traducta* (Vargas & Bernal 2009: 179: fig. 24; Domínguez & Bernal 2011: 454, fig. 4). These shell-rich models are known as far as Manilva (Málaga), 25 km north of Gibraltar.

Of the 50 to 60 *ostionera* hand-querns in the area, there is only one volcanic import (the *Baelo Claudia* example cited previously) (cf. fig. 12.8). This clearly shows that volcanic querns did not make inroads into this area and the locals remained faithful to their traditional rock. The reason remains obscure. The local querns were possibly better suited for grinding local products, in particular products derived from fish.

This spread of the biocalcarenite recalls that of analogous *grès coquillier* of the Swiss Plateau (Anderson *et al*. 2003: 67, fig. 75). The Swiss shell-rich sandstone, by far the dominant stone of the Swiss Plateau, was "surrounded" by volcanic imports both to the south. This is seen by two concentrations, in the area of Geneva in the west, and around Basel to the north. These imports attained Roman Switzerland from distant quarries hundred of kilometres away by means of fluvial transport, respectively up the Rhone from the south (Massif Central or other sources) and down the Rhine from the Eifel volcanic district.

12.4.1.3. The western granite rotary quern sector

The distribution of granite querns in southern Spain is more nebulous and difficult to grasp (cf. fig. 12.8). This is, in part, because the production district is less accessible, on the fringe of our study area, and we have collected less data (in particular from local museums) and have had to rely for the most part on secondary information.

The largest assemblage of granite querns we have been able to observe is at the Museo Nacional de Arte Romano in Mérida. The precise number is not known because it was impossible, because of storage problems, to access most of the stones individually. Other smaller granite assemblages are at Quintana de Serena, Seville (León & Carmona 2006: 47), Marmorejo, Jaén (archaeological inventory: http://www.iaph.es/patrimonio-inmueble-andalucia/resumen.do?id=i5700) and in the museums of Gerena, Seville and Villanueva de Córdoba. Haba Quirós notes that in the area of Medellín, to the east of Mérida, granite rotary querns were found at the sites of Las Galapagueras, Los Novilleros, El Casquero, Los Turuñuelos and Vega de Ortiga, Peña Lobada (among others) and notes these querns are common on *villae* (Haba Quirós 1998: 306, 321, 323, 412). Finally, a granite *meta* is mentioned at the entrance of the museum of *Italica,* Seville, in a letter written in the 1940s to the then director of the National Museum Fernández de Avilés (Berrocal Rángel 2007: 282).

The spread of these granite querns (cf. fig. 12.8) sketches over a vast triangular area between Mérida, Gerena and Marmorejo. Granite production continues even further northwest, outside our study area, with a large collection of granite examples at *Conimbriga* (Portugal) (Borges 1978).

This spread is not surprising and totally logical. Granite in the form of extensive surface outcrops and naturally sculpted blocks are ubiquitous throughout the Central Iberian, the Ossa Morena and the South Portuguese geological zones.

No Roman quern quarries have been identified in this sector. We interpret their presence around Roman Mérida from the many querns in the depository of the Museum in Mérida. We also suspect quarries in the Pedroches district around Villanueva de Córdoba, at Gerena (Seville) and at Los Molares (Huelva), districts with certified millstone production in later times.

There were certainly numerous granite quern quarries elsewhere in southwestern Spain that have left little, or no, evidence. Future research will probably confirm granite to have been the dominant regional rock in this sector for rotary querns in Roman times, following a centuries-old tradition of granite workings, as seen by the granite saddle querns on display at the Early Iron Age settlement of Cancho Roano (Badajoz). The volcanic rock incursions into this granite district, as seen by a few examples at Mérida and Villanueva del Duque (Córdoba), are probably incidental and did not have a pernicious effect on the local and regional granite productions.

12.4.1.4. Sedimentary rock hand-quern distribution

Production of rotary querns of sedimentary rocks, concentrated for the most part in the central and eastern sectors of our study area, was never eclipsed by the volcanic imports (cf. fig. 12.7). It is difficult to gauge, however, the extent of distribution of these secondary productions.

Roman limestone tufa (travertine) workings of the area of Almedinilla (CO-15), inherited from the Late Iron Age tradition, endured the arrival of the volcanic models. The Almedinilla museum possesses three examples. The first, with its receptacles and radial cuttings (fig. 12.10), is typologically identical to the volcanic models, and corroborates that this local limestone tufa production persisted into Roman times. The scale of the workings was probably very modest. We do not find limestone tufa querns in large numbers elsewhere in Roman times.

Other productions seem more tenuous and most likely reflect local workings of surface blocks or modest quarry workings. Isolated sandstone and conglomerate querns are found particularly throughout the eastern sector (fig. 12.11). These stones, like those of Almedinilla, reflect the use of local rock types.

Distribution from true extractive coarse limestone quarries like that of Ibi (A-2) in Alicante is harder to gauge. In spite of having possibly produced several hundred querns, we ignore where these handmills ended up. No survey of querns in regional museums has been undertaken. At this stage, we cannot imagine that the Ibi distribution surpassed the local sphere. Its geographical position, about 100 km from the volcanic production of the Murcia and over 500 km from the Olot-Garrotxa volcanics in Catalonia could suggest that (like the presumed production of Almedinilla, CO-15), Ibi provided an economical alternative.

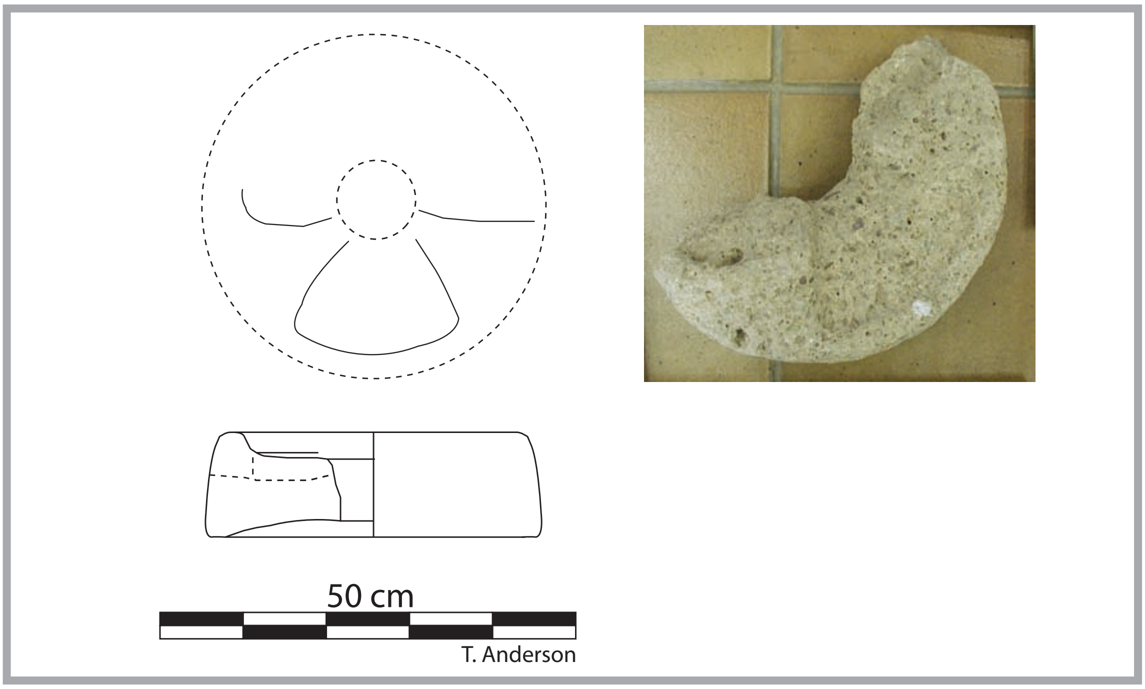


Fig.12.10: Example of a catillus scored from porous limestone tufa in the Museum of Almedinilla, Cordoba. It is equipped with fittings (receptacles and radial handle and rynd cuttings) identical to those of volcanic querns. This rock is known to have been exploited around Almedinilla since the Late Iron Age.

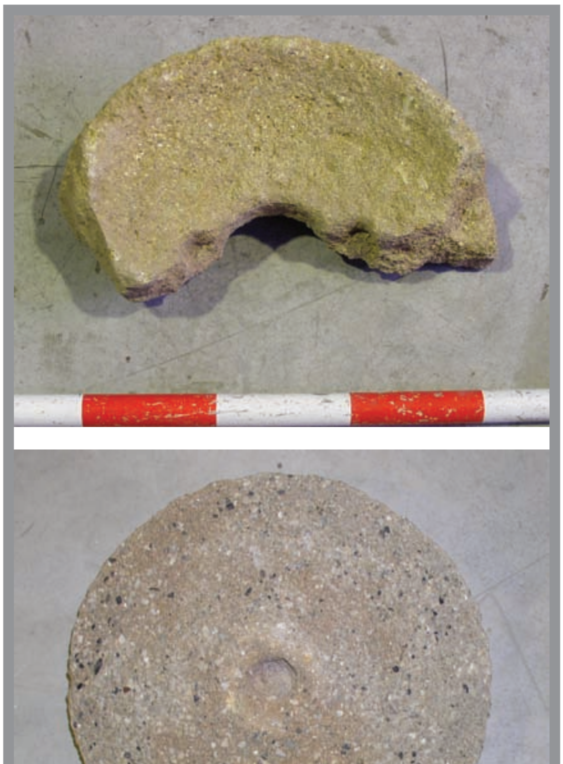


Fig. 12.11: Examples of querns scored from conglomerates stored in the Museum of Murcia.

12.4.1.5. Quantifying Roman hand-quern distribution

Throughout this work, we have freely employed the terms "local", "regional" and "long-distance" in reference to commercialisation and distribution. In general, these concepts are intangible and difficult to quantify, in particular in certain periods, devoid of written sources, when it is not possible to determine the distance between the quarry and the end-location of the millstones, at the settlement or the mill.

Through the identification of a number of rotary quern "assemblages" (often, unfortunately, consisting of a single element) and the correlation of their approximate distances to known quarry districts, we have attempted to establish numerical values for their distribution. The volcanic assemblages, with three different potential sources, are listed in table 12.1.

For the volcanic productions, we have established three reference points that serve as a basis for measurement. The Southeastern volcanics is divided into two parts: 1) the Cabo de la Gata workings are measured from a point between the quarries of Cerro Limones (AL-1) and Hoya del Paraíso (AL-2); 2) the Murcia production, comprising a number of outcrops, is measured from a central point chosen arbitrarily at the city of Mula, Murcia (about 180 km north of the Cabo de Gata). The reference point for the vast 3) Campo de Calatrava district is also established in its centre, between the cities of Puertollano and Ciudad Real. The measurements are recorded in straight lines, "as the crow flies".

As an example, the single volcanic quern from Almuñecar (Granada) (cf. fig. 12.9d), the first on the table 12.1, is 140 km from the Cabo de Gata, 260 km from the reference point for the Murcia volcanics and 235 km from the reference point of the Campo de Calatrava (fig. 12.12). These numbers are values used for comparison and do not, in fact, reflect the reality of the transport. For example, the shortest distance from Almuñecar to the Murcia volcanics is overland (260 km). But this would be a highly unlikely route because it requires crossing the Sierra Nevada Mountains. The most direct distance (235 km) to the Campo de Calatrava is a north-south overland route. The most reasonable source is that of the Cabo de Gata 140 km by sea.

Fig. 12.12: Example of the measurement values of distance between the rotary quern of Almuñecar,(Granada), and the volcanic quern production districts of Campo de Calatrava (235 m), Murcia (260 km) and Cabo de Gata (140 km). The most logical source is that of Cabo de Gata by means of maritime transport.

Table 12.1: List of the Roman volcanic rotary quern "assemblages" and their estimated distances from the volcanic production centres. The distances are measured "as the crow flies". Real travel distances over land (avoiding natural obstacles) or by sea were superior to the values in the table. The most likely source is highlighted in grey.

Roman volcanic quern sites	No. querns	Cabo de Gata volcanics	Murcia volcanics	Calatrava volcanics
Almuñecar. GR	1	140	260	235
Galera, GR	1	115	110	180
Baza, GR	10	100	150	175
Almería area, AL	4	35	185	260
Los Cazadores,AL	5	12	-----	-----
Vélez Rubio, AL	4	105	90	220
Carmona, SE	2	320	385	205
Baelo Claudia, CA	1	330	445	340
Mérida, BA	2	440	430	200
Córdoba, CO	1	265	300	130
Priego de Córdoba, CO	2	200	260	155
Villanueva de Córdoba, CO	1	285	290	75
Villanueva del Duque, CO	2	310	325	100
Almedinilla, CO	1	185	250	160
Cabra, CO	1	220	285	155
Úbeda, J.	7	175	180	110
Jaén, J.	1	180	215	125
Castulo, Linares, J	3	195	205	90
Porcuna, J	1	220	250	100
Hellín, AB	~4	-----	20	----
Bolaños, CR	1	-----	----	5
Terrinches, CR		210	135	105
Oretum, CR	7	----	----	2
Mazarrón, MU	5	----	4-	----
Murcia area, MU	21	----	c. 20	----
Cartagena, MU	3	----	c. 20	----
Aljorra, MU	2	----	c. 20	----
Villar del Obispo, V.	2	350	165	290

Table 12.2 List of non-volcanic Roman rotary quern "assemblages" (sandstones, granites, limestone tufas and biocalcarenites) and the value of the estimated distance to the nearest production centre.

Roman sites	No. querns	Rock type	Source km
Baelo Claudia, CA	40	Biocalcarenite	25
Iulia Traducta, CA	11	Biocalcarenite	55
Carteia, CA	~5	Biocalcarenite	55
Mérida, BA	c. 30	Granite	20?
Medellín, BA (various sites)	c. 10	Granite	20?
Gerena, SE	c. 2	Granite	20?
Villanueva de Córdoba, CO	2	Granite	20?
Almedinilla, CO	5	Limestone tufa	5
Zujaira. GR	1	Sandstone	3

A second table lists the quern assemblages of non-volcanic rocks (biocalcarenites, granites, sandstones and limestone tufas) (table 12.2).

The limestone tufa and sandstone querns are very near, less than 10 km, their reputed sources. The biocalcarenite quern assemblages, all near Gibraltar, come indubitably from outcrops along the 100 km corridor between the cities of Tarifa and Chipiona (Cádiz). The closest known quarries to *Baelo Claudia* (Trafalgar CA-1, the Punta Camarinal/Punta Paloma (CA-2a-b) are less distant, respectively 25 and 5 km away. The two Roman cities by Gibraltar (*Iulio Traducta* and *Carteia*) are farther away, with value distances of 55 km.

The distance of production site to the end-site of the granite assemblages is the most difficult to quantify because potential granite outcrops cover thousands of kilometres throughout the Central Iberian, Ossa Morena and South Portuguese geological zones (representing about 20% of the Iberian Peninsula!). Granite, contrary to volcanic rocks, does not leave signatures of provenance that can be interpreted from geochemical analyses. The four assemblages, nonetheless, are each found directly in municipalities with a long tradition of granite extraction and it does not seem likely that the Romans would have imported granite millstones from long distance quarries when they had access to granite in their own "backyard". For this reason, we have assigned them an arbitrary value of 20 km qualified with a question mark (20?).

From all of this data listed in tables 12.1 and 12.2, we have designed a stacked histogram combining the number of quern assemblages with the distance to their sources indicated in estimated kilometre values (increments of 10 from 20 to 330 km) (fig. 12.13).

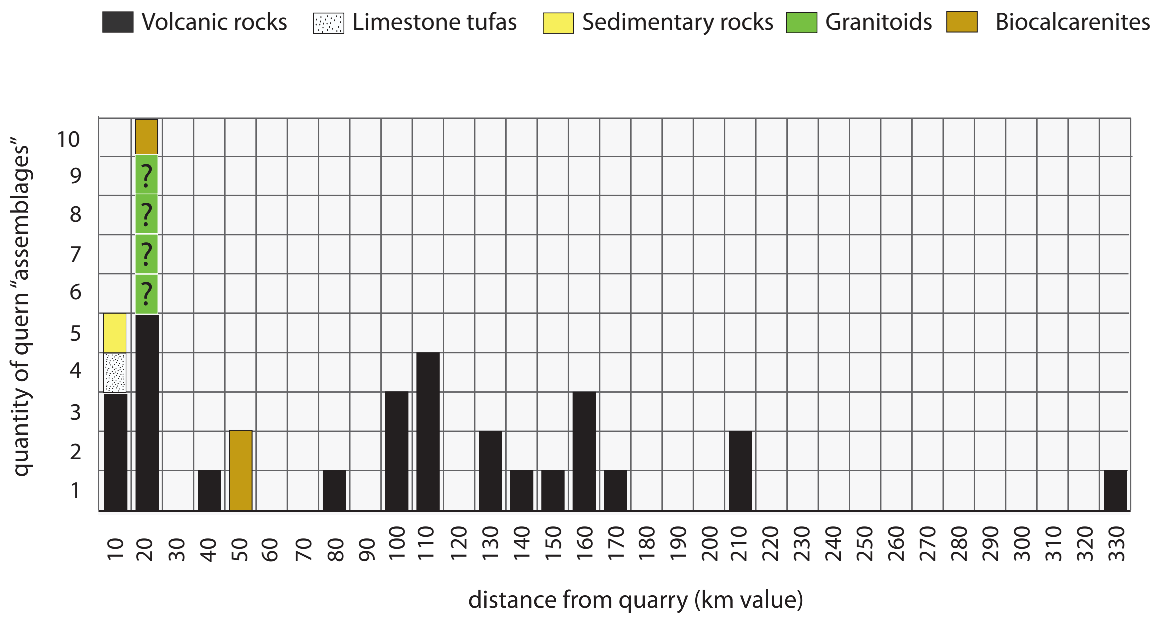


Fig. 12.13: Histogram illustrating the quantity of Roman rotary quern "assemblages" according to their minimal distance to their sources. The graph is based on the shaded values of Table 12.2. Five rock types are represented. The isolated example to the right of the chart is a volcanic quern at Baelo Claudia, approximately 350 km from the nearest source (Cabo de Gata). From this, we interpret that in Roman times local quarries serve a sphere of about 20 km. Regional quarries supply querns over a range of 40 to 50, possibly 80 km. Transport from long-distance quarries surpasses the value of 100 km. The km values are estimated "as the crow flies". Real overland or water transport distances were always greater.

The histogram suggests the following tendencies:

1) The first, with a value of up to 20 km, is indicative of **local productions**. This could be stretched to about 30 km, depending on the real (unknown) situation of the granite productions. This group encompasses most of the sedimentary assemblages, a few volcanic assemblages (sites near the outcrop) and the granite assemblages.

2) The second group, encompassing the values of 40 and 50 km (and stretched to 80 km) corresponds to **regional productions**. The number of assemblages is modest and comprises part of the biocalcarenite and volcanic productions.

3) The third group, well-represented with values between 100 and 210 km, corresponds to **long-distance productions** and comprises only volcanic quern assemblages. The single *Baelo Claudia* quern, with a value of 330 km, is the quern that has travelled the farthest from its source.

The results of this graph could be considered a simple confirmation of the obvious. It is, nonetheless, the first time in our study area that quantitative values have been attached to spheres of commercialisation. Our hope is that these numbers serve as a reference for future research.

A comparison of these numbers with recent studies on the circulation of rotary querns in eastern France and Switzerland in Antiquity is interesting. Granite, schist and gneiss querns are most likely local workings of erratic blocks and did not travel far from their sources; the *grès de la Serre* in the Franche-Comté only circulated between 50 and 60 km; the *grès coquillier* from the Broye district in western Switzerland (Cantons of Fribourg and Vaud) travelled between 60 and 80 km; the *grès coquillier* of the Swiss Würenlos district in the Canton of Aargau circulated about 40 km; most of the *Bundsandstein* of the Vosges travelled between 40 and 80 km (Jaccottey *et al*. 2007: 225-227). These local and regional productions were complemented by imported volcanic querns arriving by fluvial transport from the Eifel in Germany and the Massif Central in France. The distances of distribution of the local and regional productions are estimated to between 40 and 80 km, and are compatible with those of our study area in Spain. The long-distance volcanic imports in eastern France and Switzerland arrive from districts that are between 300 and 400 km away, a distance that surpasses the range of 100 - 210 km in our study area.

The information gleaned from this quantification does not take into account petrographical analyses in our study area that are currently in an incipient phase (analyses of 10 volcanic samples from the Murcia and Mazarrón assemblages are currently underway in collaboration with Jane H. Scarrow and Aitor Cambeses, of the Geology Department at the University of Granada). Preliminary results indicate, notwithstanding, that the Murcia millstones are lamproites, a type of rock limited to a series of outcrops in the northern half of the SE Spanish volcanic province and exclude the option that they were made in the Cabo de Gata.

To conclude this section, let us return to the volcanic *catillus* from Almuñecar cited above. The question of its provenance is certainly more complex than reflected in the chart. The quern is from the coastal city of *Sexi*, an ancient centre with strong Phoenician links through maritime trade. All would point to the Cabo de Gata, 140 km to the east, as its source. Although it does conform typologically (radial rynd-handle slots, receptacles) to the Cabo de Gata production, its greyish vesicular surface does not resemble the reddish-violet dacites and rhyo-dacites of the Cabo de Gata. Based on these macroscopic observations, either there is another unidentified quern production in the Cabo de Gata (see for example quarry AL-11 in the catalogue), or it was brought by sea from the Murcia volcanic district, farther north. This, however, can only be proved by petrographical analyses. In any case, this quern remains an example of long-distance trade.

12.4.2. Roman Pompeian and cylindrical mill distribution

12.4.2.1. Roman Pompeian mill distribution

As we have noted previously (chap. 3), there is also the problem of assigning the many bell-shaped lower stones (*metae*) throughout the landscape of Southern Spain to either cylindrical ring-*catilli* or the Pompeian "hourglass" upper stones (*catilli*). Our hypothesis, presented recently in an article for the transactions of the Colloquium of Lons-le-Saunier, France, and based on a number of petrographical analyses, is that the majority of the relatively few Pompeian *catilli* (about a dozen) spread over the whole of the Iberian Peninsula are long-distance imports from volcanic districts elsewhere in the Mediterranean Bassin, such as Mulargia, Sardinia or Orvieto. Only the cases of *Baelo Claudia* and *Malaca*, the first a roughout of local biocalcarenite and the second a limestone (also local?), can be considered to have been produced in *Hispania*. This suggests, based on the current state of research, that the Pompeian mill never really caught on in Roman Spain as it did elsewhere in the Empire, for example in Narbonese France (Jaccottey & Longepierre 2011: 100, fig. 3). Furthermore, there is no evidence that this model was produced in the quarries we have identified in the volcanic centres of Campo de Calatrava or the SE Spanish volcanic province.

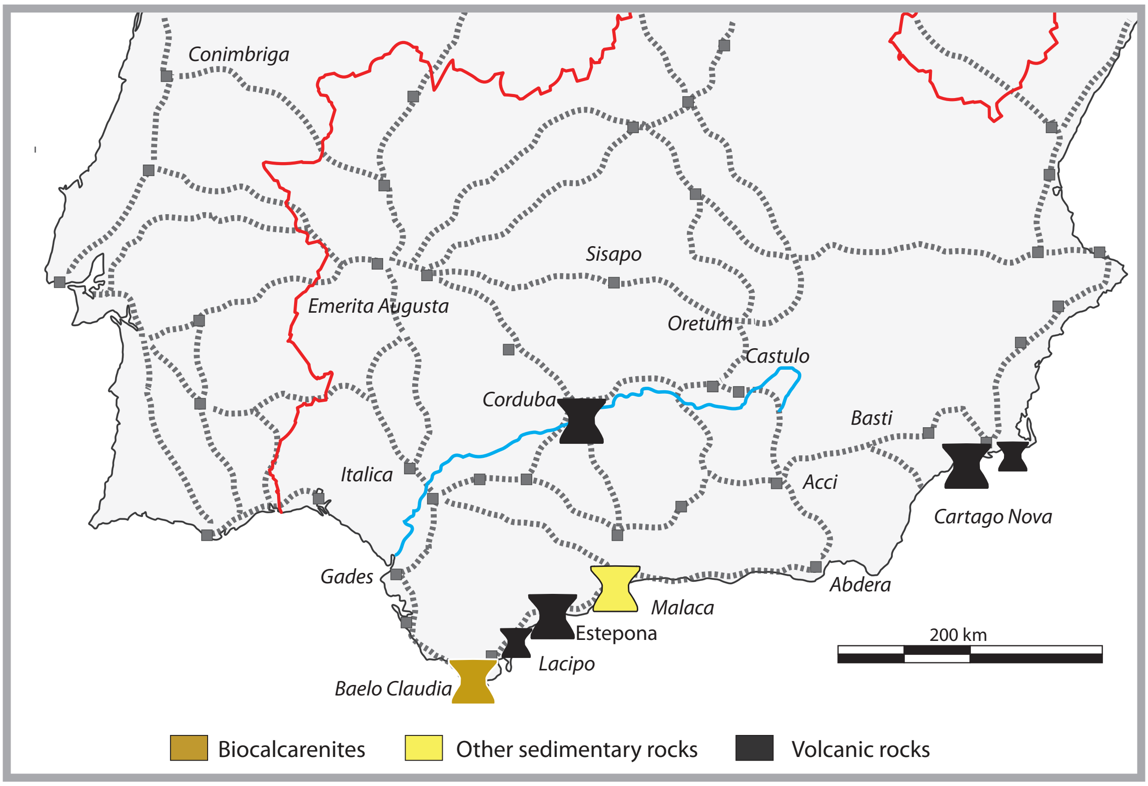


Fig. 12.14: Spread of certified Roman Pompeian mills in southern Spain (based on the presence of an hourglass-shaped catillus). In our study area most are volcanic and found along coastal settlements suggesting long-distance maritime imports. There is no evidence of Pompeian volcanic production either at Campo de Calatrava or the SE Spanish volcanic province. The examples of Baelo Claudia *and* Malaca *are certainly local copies with local rocks of imported models.*

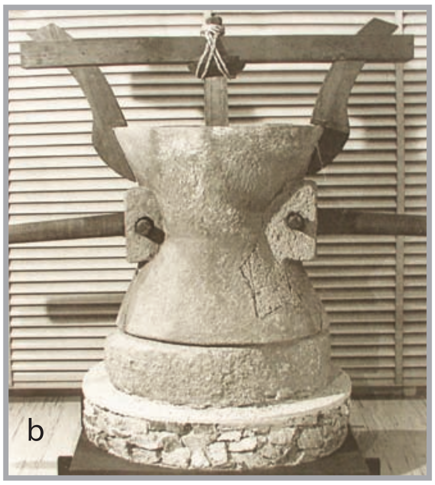


Fig 12.15: Volcanic Pompeian catilli *from the Museo de Bellas Artes de Córdoba and from the Museo Arqueológico de Murcia. The typology and petrography of these stones point to an origin in the Orvieto volcanic district near Rome (right: photograph by the Museo de Murcia).*

In our study area, there are only seven hourglass-shaped upper stones (fig. 12.14). In previous pages, we have described the exceptional example from *Lacipo*, a precursor of the Pompeian type. A "classical" Pompeian (fig. 12.15a), currently in the Museo de Bellas Artes of Córdoba (inv. DJ1069A) (Berrocal 2007: 281, fig. 4.4), is the only "inland" example in our study area. The director of the museum of Córdoba (J.-M. Palencia) informed us that its place of discovery is not certain because Julio Romero de Torres, the largest donor to the museum, was an avid early 20th-century collector and could have acquired it elsewhere in Spain. A second "classical" Pompeian (fig. 12.15b), brought to light in Mazarrón, is in the Museum of Murcia (inv. 957) (cf. chap. 3, fig. 3.21).

Based on typological criteria, notably the shape of the handle cuttings and the "band" around the girths of both the Córdoba and Mazarrón models, these two are long-distance imports, presumably from the leucite outcrops of Orvieto, near Rome, a district that accounts for a large number of the mills at Pompeii and Ostia (Peacock 1989) and throughout the Narbonese Province in France (Jaccottey & Longepierre 2011). In the Mazarrón case, preliminary petrographical analyses by J. H. Scarrow and A. Cambeses of the University of Granada second this notion.

Fig 12.16: Pompeian hourglass catilli from the Museum of Melilla (photograph by Museo de Melilla). These are examples of production at Farkhana, a volcanic outcrop by Melilla, that could have supplied millstones to Roman Hispania.

The source of the minute volcanic *catillus* in the ARQVA museum of Cartagena, Murcia (inv. 88021) is completely unknown. This example, smaller than some hand-querns and devoid of protruding handle lugs, has no typological parallel. The provenance of the *catillus* the Museum of Estepona, Málaga is also unnown. Both are possibly from shipwrecks, suggesting long-distance maritime imports. In the case of the larger Estepona mill, a potential source is the volcanic district of Farkhana in northern Africa, beside the Spanish enclave of Melilla. The Museum of Melilla, in fact, possesses two broken *catilli* roughouts presumably fabricated at Farkhana (fig. 12.16). But besides this potential example, there is no evidence that Pompeian millstones crossed the few hundred kilometres stretch between Farkhana and the southern coast of Spain.

As we have noted in chapter 3, besides the long-distance imports, there are two indigenous Pompeian productions (fig. 12.17). The unfinished biocalcarenite *catillus* at the city of *Baelo Claudia* was probably recycled from locally extracted construction material. The second is an old find in the Málaga Museum (inv. A/CE4841) from the *Alcazaba*, a Moorish fortification covering the remnants of the old Roman city of *Malaca* (Berrocal 2007: 282, fig. 5a). This is interpreted, pending more precise analyses of provenance, as a copy of a Pompeian volcanic model scored from local limestone (Anderson *et al*. 2011).

All said, the portrait of the spread of Pompeian models across the Iberian Peninsula reflects a combination of a small number of long-distance imports combined with a few local or regional copies. This model combining volcanic imports and local copies is also recognised in the north of France. In this case, the few volcanic Pompeians are combined with copies scored from local Fosses-Belleu sandstone (Jaccottey & Longepierre 2011: 100-103, fig. 4).

Fig 12.17: Pompeians catili. a) roughout of biocalcareninte (ostionera) from the Roman centre of Baelo Claudia; b) coarse limestone from the Roman centre of Malaca.

12.4.2.2. Roman cylindrical mill distribution

Apart from the Pompeian mill, the other large "industrial" Roman mill in our study area is the cylindrical mill (fig. 12.18). This model, characterised by a ring-*catillus* and a bell-shaped *meta,* is at times referred to as the *Volubilis* type because of its strong representation at the Roman city of *Volubilis* in northern Morocco

Ponsich identified a large number of these mills in his different surveys of Roman settlements throughout the Guadalquivir River Basin (Ponsich 1974, 1979, 1987, 1991). Peña Cervantes has more recently taken up the subject in her study of oil presses in *Hispania Baetica* and published a distribution map (Peña Cervantes 2010: 110, table 14; 155, fig. 19). Her distribution map, devoid of indication of rock type, forms the backbone of the illustration presented in fig. 12.19. The map is completed by the mills we have observed in museums (petrography in colours). In any case, it is evident that the cylindrical mill was widespread throughout southern Spain and outnumbered by far both the Pompeian model and the hydraulic mill, a type that is practically not represented in *Hispania* (at least at this stage of research).

The dominance of this type of mill in this area follows the logic that it is the direct descendent, from the point of view of morphology and petrography, of the large mills brought to light in settlements, often *in situ* on podiums, of the Late Iron Age Iberian Culture.

Although the vision of the spread is truncated by incomplete data, it is possible to distinguish a concentration of volcanic millstones in the eastern sector. This reflects the millstone workings in quarries like those of *Sisapo* (CR-1) and Las Herrerías (CR-2) in the Campo de Calatrava, where large extractions corresponding to these mills have been identified. There are certainly other still unidentified Calatrava outcrops that also produced these mills.

Cylindrical mills are also known to have been produced in the lamproite exploitations in the northern sector of the SE Spanish volcanic province, based on preliminary analyses by the geologists J. H. Scarrow and A. Cambeses. The exact outcrop among a number of potential sites, however, has not been identified. Cancarix (AB-2), in Albacete, with its large columnar jointing is a likely candidate. In the Cabo de Gata, by contrast, there is no evidence of large cylindrical mill workings. The columnar jointing here is probably too small to permit scoring these mills.

*Fig 12.18: Example of a cylindrical ring-*catillus *from the Roman city of* Castulo *(Jaén),ø: 64 cm (photograph Linares museum, inv. no. CE01430_R). The lower stone (of undetermined rock) is not its original couple.*

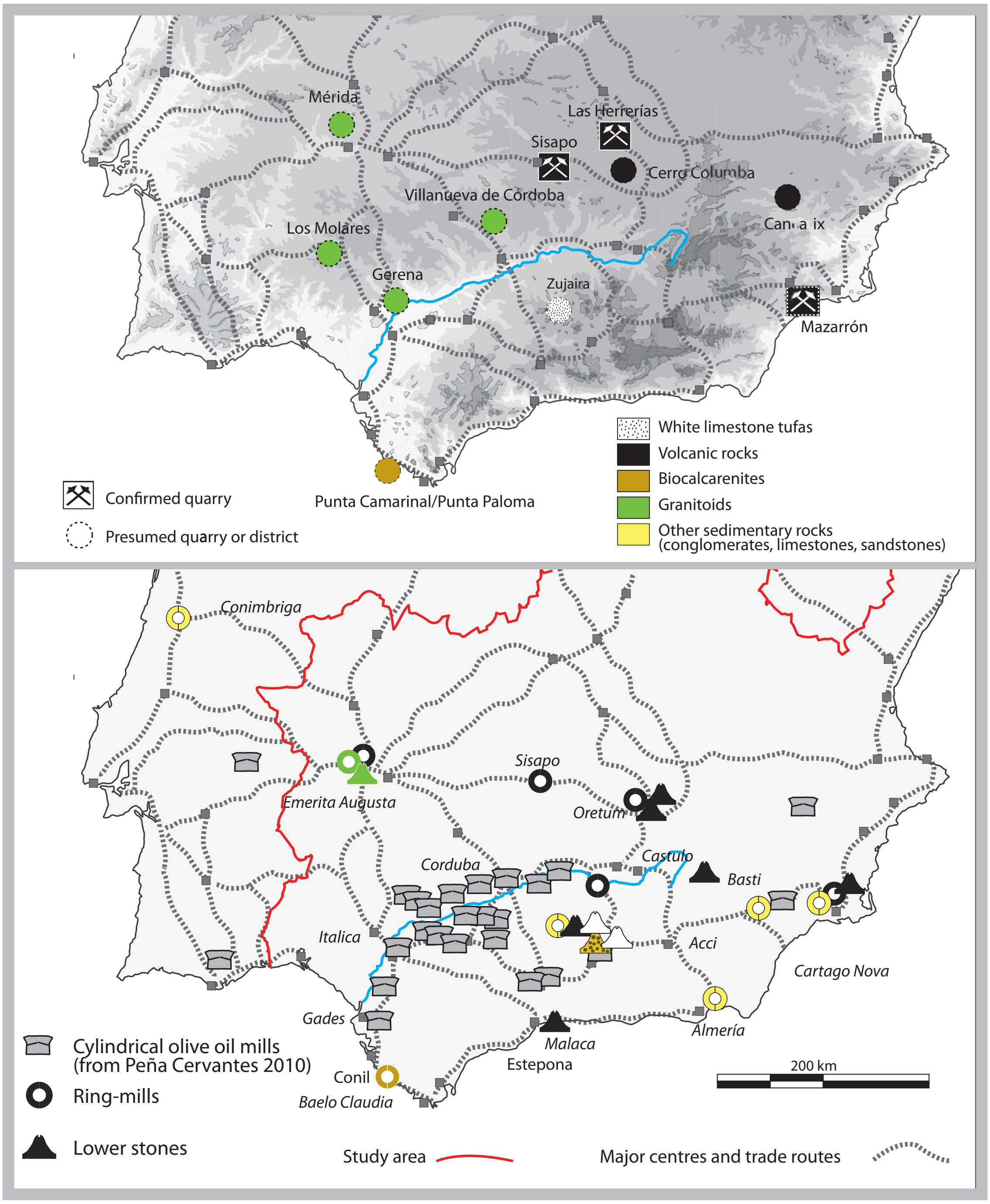


Fig. 12.19: Top: Location of quarries and quarry districts producing or cylindrical mills. Spread of cylindrical ring-type mills. The grey symbols, concentrated for the most part along the Guadalquivir River Valley, represent cylindrical mills of unknown petrography reputed for the olive oil industry (from Peña Cervantes 2010: 115, fig. 19). The other symbols are ring-catilli or metae, by rock type. Cylindrical mills are by far more prevalent in southern Spain than Pompeian mills.

Fig 12.20: Los Zurriones, Priego de Córdoba. Roca carniola, porous compact limestone.

In Mérida, as expected, there are granite cylindrical mills and a few volcanic models, suggesting mainly local granite productions coupled with a few long-distance imports, probably from the Campo de Calatrava.

Elsewhere cylindrical mills were hewn from sandstones and conglomerates. In Priego de Córdoba a few of these were scored from a very hard local limestone called *carriola*, a rock that, on the surface, resembles travertine, but comes from a much older (tertiary), more compact geological unit (fig. 12.20). The single biocalcarenite example from Conil, Cádiz, would, as expected, have come from a local *ostionera* exploitation.

Fig 12.21: Lower stones (metae) at the archaeological site of Oreto y Zuqueca, Ciudad Real of local or regional volcanic rock.

12.5. Millstone distribution in the Middle Ages

The corpus of millstones dating to the Middle Ages in museum depositories and archaeological reports (and there are few) are rotary hand-querns. That only the smaller models are published or in museums is not surprising, and not only necessarily related to the logistical problems of storage of the larger models. In the case of the Cerro del Castillón outside of Montefrío, Granada, the fact that only the smaller models appear in the records of the excavation is logical (Motos Guirao 1987). The settlement was located on the top of a plateau at an average height of about 1100 m. The place to look for the larger hydraulic millstones would not be at the settlement, but a few hundred metres away, along the streams. Therefore, little can be said about the distribution of millstones that equipped the Visigothic and later Moorish watermills along the rivers, streams and irrigation ditches.

Historical documents for this period are also almost nonexistent (or unavailable). The only record we have identified is a contract dating to 1114, related to the lease of a watermill along the River Guadalbullón near Jaén recording that after restoration of the mill, four composite millstones (in 8 segments) would be brought from Arnedo (Lagardère 1991: 109). The location of Arnedo is problematical. A quarry has been identified in northern Spain by P. Pascual and P. García 600 km away in Arnedillo, beside the town of Arnedo in La Rioja (Pascual & García 2011: 286). This is not likely the source because Pascual and García describe it as very modest (*Atlas of European Millstones*; http://meuliere.ish-lyon.cnrs.fr/). Furthermore, in 1114, Arnedo was under Christian control, complicating a potential exchange. The only potential quarry is that of Villargordo (J-8), a few kilometres away. But this site is only certified three centuries later (Córdoba de la Llave 2003: 306, footnote 26) and cannot be linked with certainty to the quarry mentioned in the lease.

In any case, due to the widespread deliberate decrease of use of volcanic rocks in Late Antiquity or at the outset of the Middle Ages (Amouric 1997: 46-47; Brun & Borreani 1998: 301; Anderson *et al*. 2011: 163; Longepierre 2011: 162-163) and the rise or return to sedimentary rocks (notably with large clasts conglomerates, coarse sandstones and limestones), we find it difficult to envision the necessity in the Middle Ages for a vast commercial quern and millstone trade network on the scale of that of volcanic rocks in Roman times. The ubiquity of the sedimentary rock outcrops throughout the landscape of southern Spain, as seen through the sites of Rambla Honda (AL-3), Puerto de la Cadena (MU-1), Almadén de la Plata (SE-1) and Zagra (GR-5), rendered obsolete the necessity of importing from long-distance exploitations.

There were no doubt certain quarries in the Middle Ages possessed reputations that exceeded those of others. These would have been more coveted for the quality of their products and more costly to acquire and transport. This could be the case for the sites listed in the previous paragraph. Unfortunately, since there is no data on the end-locations of these millstones, we are not in a position to be able to paint a more precise portrait of the spheres of distribution of Medieval millstone quarries.

12.6. Millstone distribution in the Modern period

In the Modern period, by means of historical documents that record both the location of the sources of millstones and their end-locations, we begin to have a clearer vision of the commercial reach of certain quarries. We cannot establish distribution maps based on petrography, like those we have presented to illustrate distribution in Antiquity, because the heavy and cumbersome millstones that equipped Modern watermills, windmills and *tahonas* are never stored in museums. Most have probably vanished because their milling installations have disappeared or undergone subsequent transformations.

The historical documents we have been able to access, through molinological studies, stretching over the period of 1491 to 1587, record the distance travelled by millstones from nine different sites (fig. 12.21). They are presented in ascending order of the estimated distances ("as the crow flies") from the quarry to the mill.

1) In 1486, a historical document records the order of a segmented millstone for a mill in Córdoba from the quarry of Albaida (CO-7) (Córdoba de la Llave 1988: 843, footnote 23; 2003: 306, note 26). This site, known for its building material, is just a few kilometres north of Córdoba. Millstone production certainly benefited from the transportation network established for the construction material. A cart loaded with a millstone would have taken less than a day to cover the distance. We ignore the volume of millstone production and, if millstone production at Albaida was great, whether Córdoba was used as a post for export to other regions.

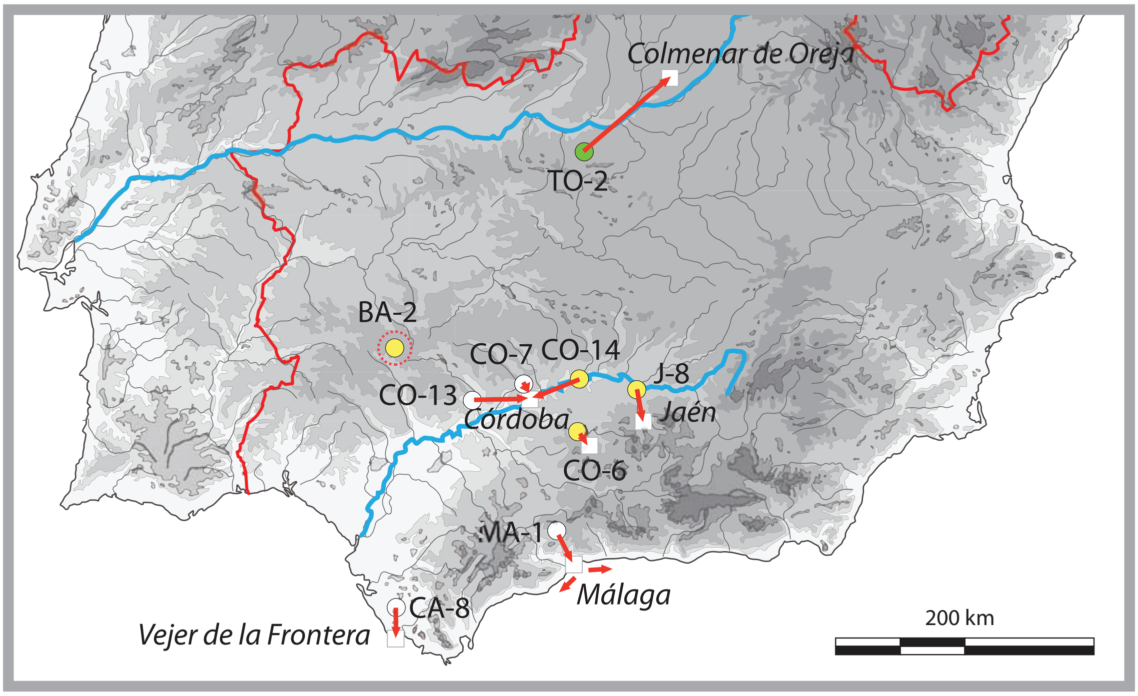


Fig. 12.21: Map indicating the ranges of distribution of 9 millstone quarries from the Modern period (1481 to 1576). Most ranges do not surpass 40 km. The sole long-distance example is from Ventas con Peña Aguilera (TO-2) to Colmenar de Oreja, Madrid. Most transport was by land. The option of fluvial transport along the Guadalquivir River was possible, although not documented, from Hornachuelos (CO-13) and Montoro (CO-14) to Córdoba. By contrast, transport by sea of millstones from Antequera (MA-1) via Málaga to nearby coastal towns is certified by written sources.

2) In 1557, a notarial protocol records the order of a millstone from the quarry of Izcar (CO-6), Córdoba for the Molino de la Piedra, a watermill 9 km away, south of the city of Baena (Córdoba de la Llave & Varelo 2012: 106).

3) In 1566, a Municipal Ordinance at Llerena, Badajoz, decreed the prohibition of "foreigners" to extract millstones unless they, like the locals, paid the official tariff (Chapter CXCVII of the ordinances; Maldonado Fernández website: http://manuelmaldonadofernandez3.blogspot.com.es/2010_04_01_archive.html). Although there is no indication of the distance of transport, we suppose that this ordinance implied a radius of distribution at least 10 km, probably more, the average distance to the towns of the neighbouring municipality.

4) In 1499, a notarial protocol records the order of a millstone for the Molino Nuevo (presumably in Jaén) from the *molar* (quarry) of Villargordo (J-8), about 20 km away (Córdoba de la Llave 2003: 306, footnote 26).

5) In 1509, a historical archive indicates that the Berruecos quarry near Medina (CA-8), Cádiz furnished a millstone to a watermill "La Teja" in Vejer de la Frontera, 20 km away (http://www.patrimoniojandalitoral.es/f_vai_8.htm).

6) In 1500, a contention between the citizens of Antequera and Málaga was taken before the Catholic Monarchs in Granada. This feud indicates that millstones from the surroundings of Antequera (i.e. El Torcal, MA-1) were being taken at least 30 km southwards, to the city of Málaga. We do not know if the millstones of this specific feud were then commercialised farther away by boat. In 1508, however, another notarial protocol indicates that millstones from El Torcal were being traded by boat at least over short distances up and down the Málaga coast.

7) Two different protocols. from 1481 and 1486, record that millstones from Hornachuelos (CO-13) were acquired for mills in the city of Córdoba, 40 km away (Córdoba de la Llave 1988: 843, footnote 24; Córdoba de la Llave 2003: 306: footnote 26). It is conceivable that these stones were ferried up the Guadalquivir River.

8) In 1481, a *bermeja* (lower stone) from a quarry in Montoro (C-14), also 40 km away, was acquired for a mill in the city of Córdoba (Córdoba de la Llave 1988, 843, footnote 22). The millstone was probably a *molinaza*, from the famous *Bundsandstein* outcrops of Montoro. It could have been ferried down the Guadalquivir to Córdoba.

9) In 1576, a text stresses that Ventas con Peña Aguilera (TO-2) produced the "best" granite millstones in all of Spain, suggesting that this production was widely distributed. This is confirmed by a protocol in 1587, recording that the millstones for a restored watermill in Colmenar de Oreja (Madrid) "must be of *piedra berroqueña*" (granite stone) from Las Ventas con Peña Aguilera. The distance is 100 km. It is of note that this transport included crossing the Tagus River, an increment to the transport cost. Ironically two centuries later, Colmenar de Oreja would be a major producer itself of white limestone millstones for the city of Madrid.

The image we gather from the histogram (fig. 12.22) is that of a series of quarries in the Modern period supplying local mills in a radius of about 20 km, a distance that could be attained by ox-driven cart in one or two days. Other more select quarries supplied mills slightly farther away, on a regional scale, between 40 and 50 km. Only Ventas con Peña Aguilera (TO-2), with its "best granite millstones in all of Spain" (Viñas & Paz 1951: 216), traded millstones up to 100 km. These were also transported by cart and possibly ferried, as in the case of Hornachuelos (CO-13) and Montoro (CO-14), down the Guadalquivir River or, as in the case of El Torcal (MA-1), by boat along the coast of Málaga, a means of transport would have facilitated transport farther away.

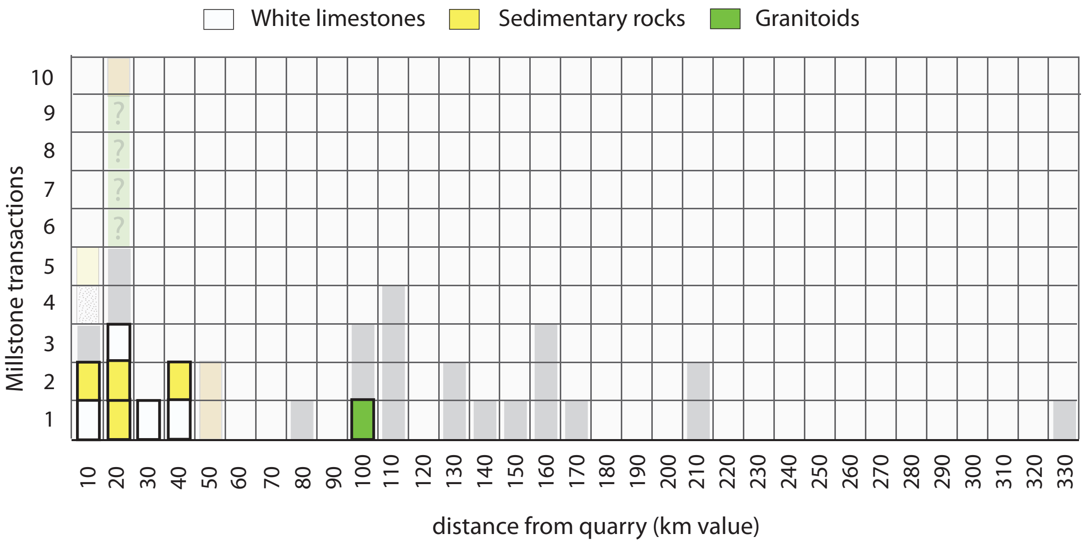


Fig. 12.22*: Histogram illustrating the quantity of millstone transactions in Modern times(1491 to 1587) based on written sources, and distances in increments of 10 km from the quarry to the mill. Compared to the graph illustrating the assemblages of Roman querns (in transparency in the background, cf.* fig. 12.13*), the number (9) is extremely low and not valid statistically. It does, nonetheless, show differences of rock types from Roman to Medieval times (notably the absence of volcanic rocks) and sets apart one "long-distance" import of 100 km (Ventas con Peña Aguilera, TO-2, to Colmenar de Oreja, Madrid) from the group with shorter distances of up to 40 km.*

12.7. Millstone distribution in Contemporary times

Distribution of millstones from the end of the 18th century until the beginning of the 20th century is deduced for the most part from written sources. In addition, the commercial reach of some sites devoid of written sources can be derived from estimating their volume of production based on field work. For example, a site with hundreds of extractions obviously did not serve a local marketr exclusively.

As in the case of the Modern period, it is not possible to illustrate distribution by mapping individual millstones as was done for the Roman period. Millstones form this period are also rarely or never in museums. Those that are available for observation, for the most part, decorate public spaces, and are mute as to their original context. They are also of rock types, sedimentary for the most part, that do not betray their origin.

The principal written sources for the Contemporary period are no longer the municipal or notarial protocols but mostly geographical dictionaries, in particular the works of Miñano and Madoz. These authors, however, provide only meagre clues as to the commercial reach of the quarries they identify. Their allusions are most often very brief, limited to simply recording the existence of a site in a municipality.

12.7.1. "Long distance" millstone distribution (over ~85 km)

From the outset it must be clearly established that there is no single quarry or quarry district in our study area that dominated the millstone market of southern Spain. No single site possessed the reputation and commercial strength of the *pedrera* of Montjuïc by Barcelona that traded its sandstones along the Catalonian and Valencian coast, even attaining southern France, the Balearic Islands and Italy. From written sources there is evidence, however, that a series of quarries in southern Spain traded their products between 85 and about 210 km (table 12.3; fig. 12.23). These numbers, although arbitrary, do reflect a distance that required that the quarry have a good reputation, better than that of other closer exploitations, and that the cost of transport be worth the effort. There are certainly other sites in our area that exported their products similar distances. This is corroborated by a Royal Decree dating to 1829, forbidding the import of 42 millstones from Portugal into the Galician city of Pontevedra. The argument behind this prohibition was that there were sufficient millstones quarries on Spanish soil to supply the country, notably the quarries of Álava in Basque Country and the quarries in Andalusia, in particular those in the Province of Granada (Ferrer 1830: 219).

1) TO-2: The quarry with the longest certified range of trade is that of Las Ventas con Peña Aguilera, near Toledo. According to Miñano, this granite district supplied millstones 30 leagues and beyond (Miñano 1828, Vol. 9: 286), a range from 120 to 210 km, or more (based on 4 to 7 km for 1 league). The larger radius of 210 km would include the city of Madrid. The commercial strength of this site was already established in the late 16th century as it was reputed to be the "best" granite millstone quarry in all of Spain (Viñas & Paz 1951: 216).

2) CA-8: The white limestone quarry of Berrueco by Medina Sidonia, famous all over Cádiz for its millstones for watermills, windmills and *tahonas* (Madoz 1846: Vol. 4: 290), is reputed to have traded its products as far as Puebla de Guzman in the Province of Huelva (Garrido 2001: 167), a distance of 170 km. From different written sources dating from the 16th century, we deduce that this was one of the most important quarries in southern Spain and is surely one of the "abundant" Andalusian quarries alluded to in the Royal Decree of June 9, 1829, prohibiting the entry into Galicia of millstones from Portugal (Ferrer 1830: 219-220).

3) CA-3: The seaside biocalcarenite exploitation of Rota, Cádiz, exploited since Roman times for hand-querns, traded its millstones in the 19th century as far as Portugal on two Portuguese ships, the "*Felicidade*" and "*O Que Deus Quera*" (Ponce 1981). We ignore, however, their final destination. The nearest Portuguese port is 110 km away. The evidence of extraction of large millstones today does not give the impression of a vast former production. It must be noted, nevertheless, that much of the site was probably destroyed during construction of the new port.

4-5) BA-1 and J-1: The quarries of Alconera in Badajoz and Castillo de Locubín in Jaén are included in this group (in spite of the absence of any evidence of distribution) because they were represented at the Universal Exposition of Paris of 1867 (Comisión Régia 1867: 187, 190). This suggests that they were coveted and their owners or representatives saw a potential to market them outside their region.

Table 12.3: List of Contemporary quarries that presumably commercialised their millstones over long distances (beyond the range of 85 km).

Code	Millstone quarry	Rock type	Bibliography
TO-2	Ventas con Peña Aguilera	Granite	Miñano 1828, Vol. 9: 286
CA-8	El Berrueco	White limestone	Madoz 1846: Vol. 4: 290
CA-3	Rota	Biocalcarenite	Ponce 1981
BA-1	Alconera	White limestone	Comisión Régia 1867: 187
J-1	Castillo de Locubín	Sedimentary	Comisión Régia 1867: 190

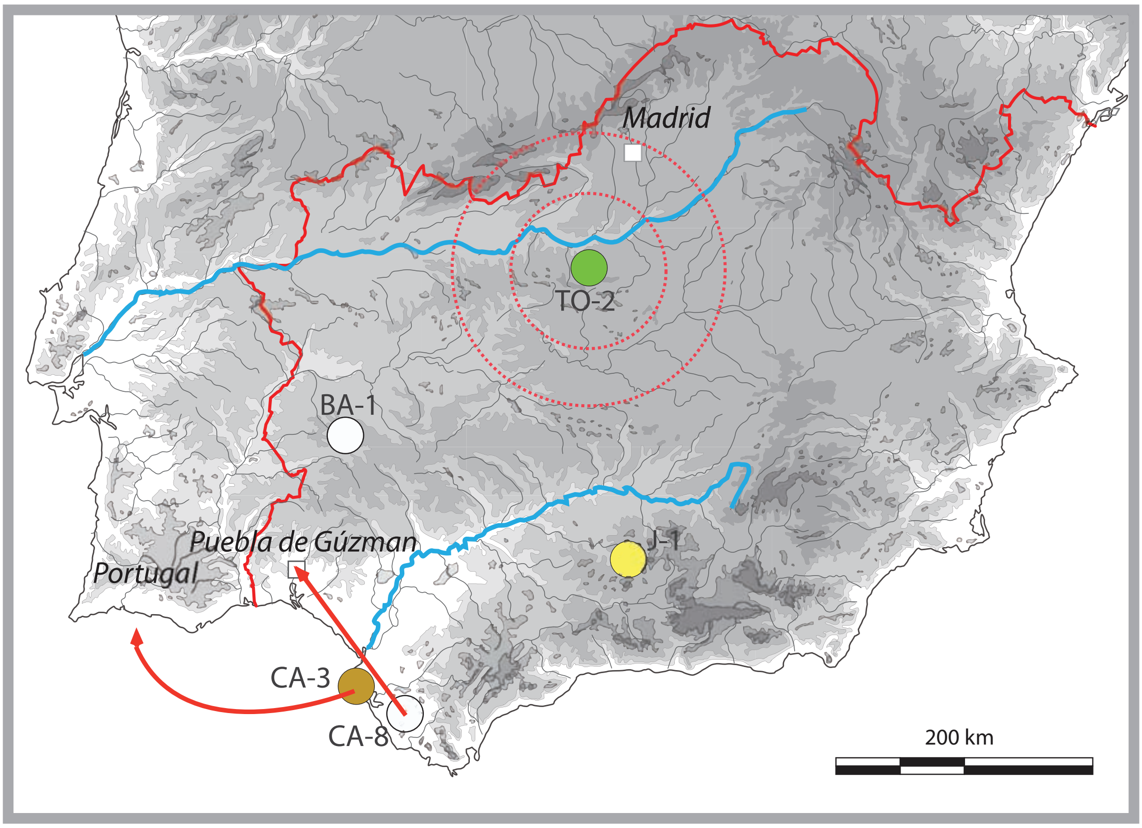


Fig. 12.23: Map of Contemporary millstone quarries with distribution of products certified by written sources surpassing the distance of 85 km. Sites: Ventas con Peña Aguilera (TO-2), El Berrueco (CA-8) and Rota (CA- 3). Castillo de Locubín (J-1) and Alconera (BA-1) are included in this group because their products were exhibited at the Universal Exposition of Paris of 1867.

12.7.2. "Longer-range" regional millstone distribution (~50 to ~85 km)

There are several sites that have certified distribution between 50 and 85 km of distance (table 12.4; fig. 12.24). These can no longer be considered "long-distance" exploitations since the cost of the transport and the distance to the destination would be considerably less. The investment in transport and time was larger than a number of "shorter-range" regional quarries. Here, the transaction would have meant a large investment for the importer.

1) M-2: The white limestone quarry of Colmenar de Oreja, Madrid is known to have supplied millstones to the *tahonas* of the city of Madrid about 50 km to the northwest (Madoz 1847, Vol. 6: 525). The production would have benefitted from the network of transport of the Colmenar construction material, well established since the 16th century.

2) GR-1: The white limestone quarry of Moclín in the Province of Granada, a supplier of millstones at the provincial level (Madoz 1847, Vol. 8: 480), was also reputed to have furnished upper stones to mills in the Alpujarra Mountains (Rodríguez Monteoliva 1989: 705), a distance of about 60 and 80 km to the southeast. These white upper stones were probably coupled with conglomerate or sandstone lower stones, the dominant rock types. The enormous size of the sites is also indicative of a wide distribution. Moclín is probably the site in Granada alluded to in a Royal Decree forbidding the import of millstones into Galicia from Portugal (Ferrer 1830: 219-220). If this reference were proven to be true, then Moclín would have to be "upgraded" to the status of a long-distance exporter.

3) CO-1: The pink *rosso ammonitico* limestone exploitation of Los Frailes, Cabra in southern Córdoba was commercialised both to the city of Málaga, 85 km to the south (Ezquerra del Bayo 1856: 385), and to the city of Córdoba, 60 km to the northwest (Montero 2008). This is also not surprising due to the large size of the exploitation and the number of vertical tubular faces that are still visible.

Table 12.4: List of Contemporary quarries that presumably commercialised their millstones over distances of about 50 to 85 km.

Code	Millstone quarry	Rock type	Bibliography
M-2	Colmenar de Oreja	White limestone	Madoz 1847, Vol. 6: 525
GR-1	Moclín	White limestone	Madoz 1847, Vol. 8: 480
Co-1	Los Frailes	*Rosso ammonitico*	Ezquerra del Bayo 1856: 385

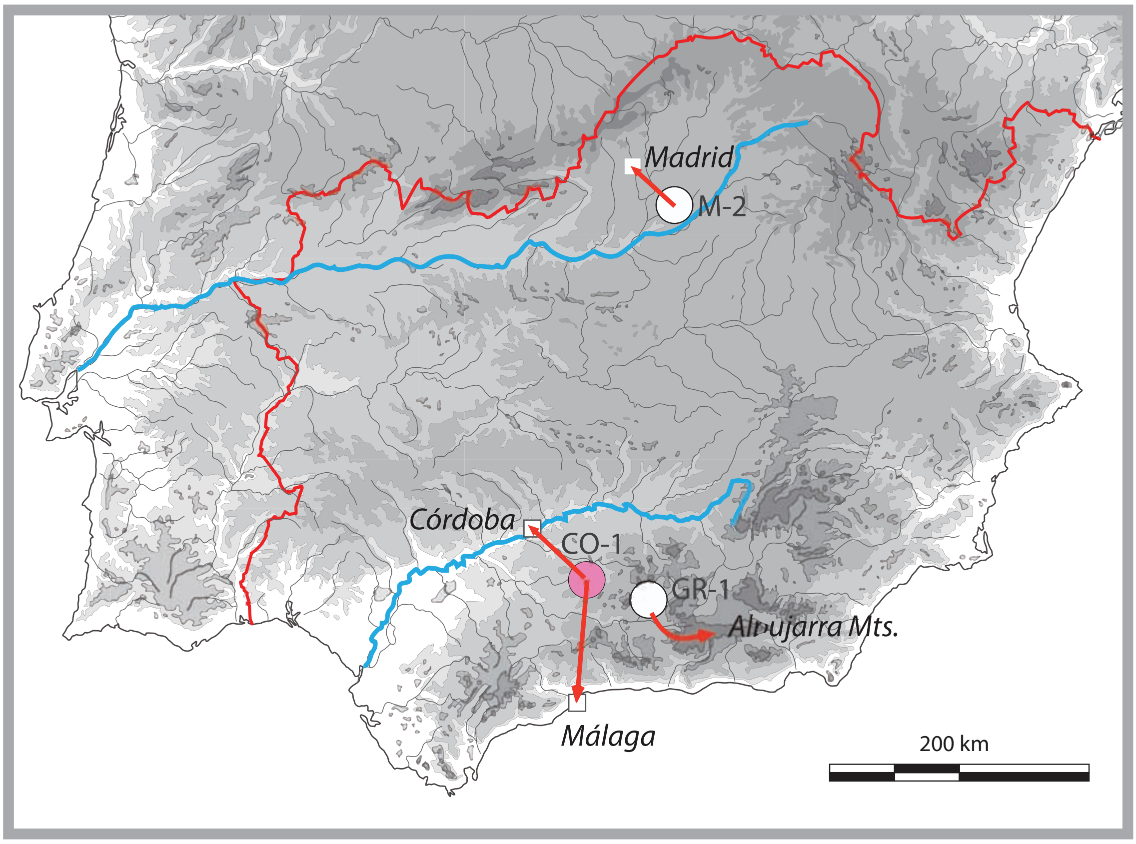


Fig. 12.24: Map of the Contemporary millstone quarries that commercialised their products distances ranging from 50 to 85 km. Sites: Los Frailes, Cablra (CO-1), Moclín (GR-1) and Colmenar de Oreja (M-2).

12.7.3. Shorter-range regional distribution (~20 to ~50 km)

The mere appearance of a written reference to a millstone quarry in publications of such status as the dictionaries of Miñano and Madoz is indicative that an exploitation was noteworthy, with workings surpassing that of a number of modest, anonymous quarries. The fine line of separation between a local and regional production is, nonetheless, difficult to quantify, especially when the texts are not very informative about the sites. Among those identified in 19th-century writings, certain sites stand out because the authors went beyond their simple identification, and qualified, although vaguely, their commercial distribution (fig. 12.25; table 12.5). Based on a computation of mills around Pinilla de Jadraque (GU-2), we place, somewhat intuitively, the limit between "local" and "regional" quarries at 20 km, a distance that could be attained by an ox-driven cart in a journey taking a whole day.

1) GU-2: Pinilla de Jadraque is described by Miñano as follows: "excellent millstones are extracted from its precious quarry for other towns" (Miñano 1827, Vol. 7: 24). We have attempted to quantify this statement by recording the number of flour mills in the hamlets and towns in a radius of 20 km. To accomplish this we have consulted the entries of 21 towns in the Madoz dictionary (1845-1850) (Miñano's texts are not complete enough). In the 21 towns and hamlets around the quarry, there are 13 flour mills (see annex 4). Supposing that each mill required one millstone replacement every year (which was not necessarily the case), then the yearly production of 13, a number that seems very low for a site mentioned in a geographical dictionary. Even doubling that number would imply only a few months of work for only a small team of workers (based on 1 extraction every 4 to 7 days, cf. Maestro Hernández 2011: 43-44). We therefore infer that in his use of the words "for other towns" Miñano alluded to a distance beyond 20 kilometres.

2) GR-6: The situation of the white limestone quarry of Alhama de Granada, Fuente de los Morales is similar to that of Pinilla de Jadraque. Madoz states that its millstones were commercialised all over the area, even as far as to towns in the Province of Málaga (Madoz 1847, Vol. 8: 216). The towns most certainly referred to by Madoz are to the southwest of the site (Alfarnate, Perirana, Viñuela, Canillas de Aceituno), over the Málaga mountains, at an average distance of about 25 km.

3) CO-10: The conglomerate quarry along the Albardado stream near Belmez, Córdoba produced, according to Madoz, both for the towns in the immediate vicinity and for towns "even farther away" (Madoz 1846, Vol 4: 131). In this case, the closest towns are Belmez, Peñaroja-Pueblonuevo and Villanueva del Rey, less than 10 km away, whereas a handful of more distant towns (Fuente Obejuna, Villanueva del Duque, Pozoblanco, Espiel) range from 18 to 30 km.

4) BA-2: The sedimentary (limestone, limestone tufa or arkose) quarry of Llerena, Badajoz, according to the census of 1791 (Caso Amador 2008: 133), provided millstones to "many towns in the area". The few immediate towns are in a radius of 10 km. To reach a higher number of towns the radius must be expanded to between 15 and 30 km.

5) CC-2: The granite quarry of Villar de Plasencia, Miñano states that millstones were extracted from surface rocks "... and transported "4 and 6 leagues away" (Miñano 1828, Vol. 9: 433). The town is on the *Via de la Plata* (Silver Way), an ancient and important N-S thoroughfare dating from Roman times. The statement by Miñano indicates a distance ranging from 16 to 42 km. Due to access to the important ancient road we suppose the quarry supplied millstones beyond the local sphere.

6-7) GR-10 and GR-2/3: Madoz, when describing the rock productions of the Province of Granada, mentions millstone workings at Moclín (GR-1), Vélez de Benaudalla and Loja (Madoz 1847, Vol. 8: 480). Due to the citing of these three productions, all of white limestone or dolomite, we suppose they stand out over the other productions in the province and must have had a wider range of distribution.

8) GR-11: The conglomerate quarry of Rambla de las Canteras, outside of Caniles, Granada, was known for stones that yielded dark flour (Madoz 1846, Vol. 5: 461). We cannot conceive that the production of this easily accessible quarry, with its long, parallel trenches, remained inside the local sphere.

Table 12.5: List of Contemporary quarries that presumably commercialised their millstones over distances of about 20 to 50 km.

Code	Millstone quarry	Rock type	Bibliography
GU-2	Pinilla de Jadraque	Limestone tufa	Miñano 1827, Vol. 7: 24
GR-6	Fuente de los Morales	White limestone	Madoz 1847, Vol. 8: 216
CO-10	Albardado	Conglomerate	Madoz 1846, Vol 4: 131
BA-2	Llerena	Sedimentary	Caso Amador 2008: 133
CC-2	Villars de Plasencia	Granite	Miñano 1828, Vol. 9: 433
GR-10	Vélez de Benaudalla	White limestone	Madoz 1847, Vol. 8: 480
GR-2/3	Loja	White limestone	Madoz 1847, Vol. 8: 480
GR-11	Rambla de las Canteras	Conglomerate	Madoz,1846, Vol. 5: 461

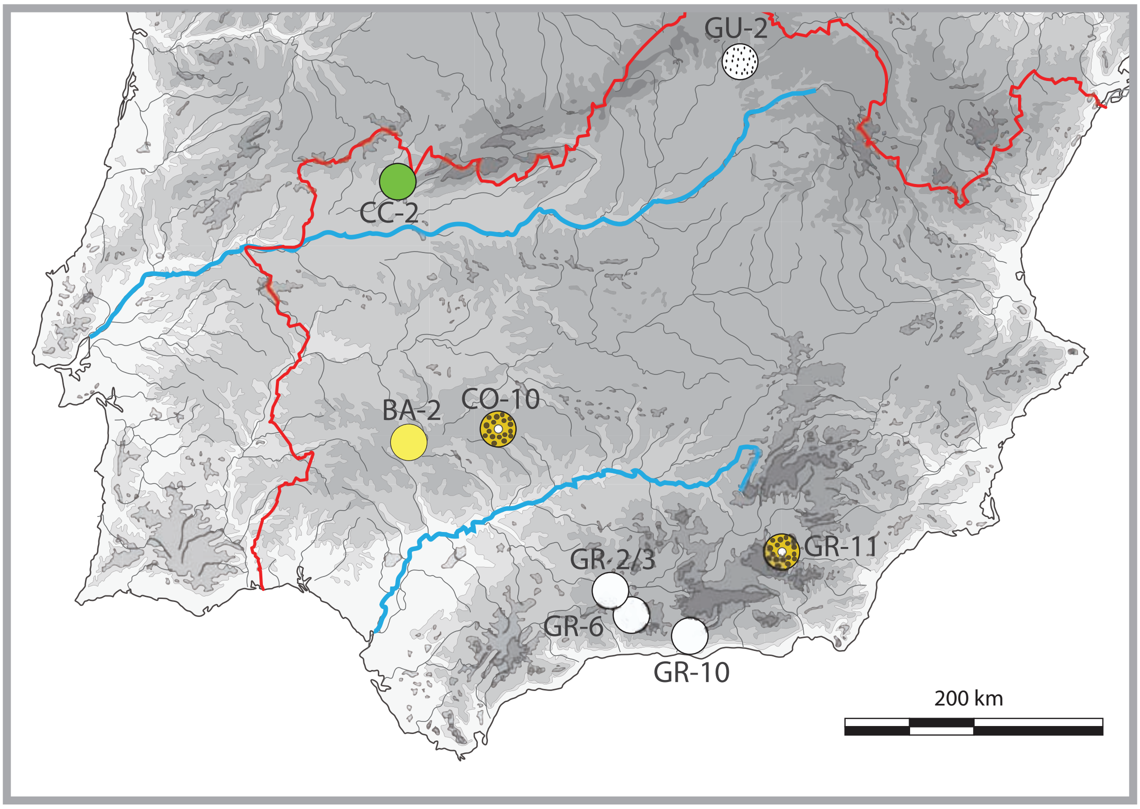


Fig. 12.25: Map of Contemporary millstone quarries that appear, according to 19th-century texts, to stand out above local millstone quarries with a sphere of distribution of between approximately 20 and 50 km..

12.7.4. Local distribution

Local distribution of millstones is defined roughly as sites with a modest volume of production limited to the sphere of about 20 kilometres, a distance that could be attained by an ox-driven cart in one or two days. There are a number of sites of this type in our study area. The quarries of Guájar Faragüit (GR-8) and Carchuna (GR-9) in the Province of Granada are examples with only about a dozen visible extractions. The workings of Cambil (J-4) and Molino de la Piedra (CO-5) are even more modest. None of these can be considered anything but local productions. The problem of these sites is that they are not recorded in old texts and therefore cannot be placed securely into any chronological period. In the case that they were Contemporary, however, it is doubtful, considering their modest, almost insignificant production, that they would have been included in the pages of old texts and 19th-century geographical dictionaries.

There are nonetheless 32 sites certified from Contemporary times by means of old texts that do not show any evidence of regional distribution (fig. 12.26; table 12.6). This absence of data does not permit us to assume that they did not export their stones beyond a local sphere. At this stage, however, we cannot assume they were anything but local quarries.

El Torcal (MA-1) is a special case. This site, with its long tradition of millstone workings since the late 15th century, cited by García Leña (1789), is no longer mentioned by Miñano or Madoz a half-century later. We ignore if this is simply an omission by the authors, or if we can interpret it as a decrease or halt in production. All said, this group of sites completes the vision of the distribution of millstones in Contemporary times.

Table 12: 6: List of millstone quarries or quarry districts cited by written sources from the middle of the 19th century. There is no evidence of distribution from these sites beyond a local sphere. The sheer mention of the sites in the volumes of Madoz, however, sets them above other anonymous productions.

Code	Millstone quarry	Rock type	Bibliography
MA-1	El Torcal	*Rosso ammonitico*	García de la Leña 1789: 106
MA-7	El Jabonero	Coarse limestone	García de la Leña 1789: 106
M-4	Chapinería	Granite	Miñano 1826, Vol. 2.: 83
GU-1	Brihuega	Limestone tufa	Vallejo 1833: 387
AL-8	Adra, Cerro el Chispa	Conglomerate	Madoz 1845, Vol. 1: 88
AL-9	Vera	Sedimentary	Madoz 1850, Vol. 15: 670
J-3	Huelma	White limestone	Madoz 1847, Vol. 9 : 260
J-5	Andújar, Los Morales	Granite	Madoz 1845, Vol. 2: 305
J-6	Andújar, El Pedroso	Granite	Madoz 1845, Vol. 2: 305
J-7	Linares district	Granite	Madoz 1847, Vol. 10: 290
CO-9	Los Arenales	Sedimentary	Madoz 1849, Vol. 15: 136
CO-16	Minas de Espiel district	Sandstone	Madoz 1849, Vol. 14: 382
CO-17	Fuente Obejuna	Undetermined	Madoz 1847, Vol. 8: 230
MA-2	Teba	White limestone	Madoz 1849, Vol. 14: 752
MA-3	Alhaurín el Grande	Sedimentary	Madoz 1845, Vol. 1: 604
MA-5	Guaro	Sandstone	Madoz 1847, Vol. 9: 56
MA-6	Alozaina	Conglomerate	Madoz 1845, Vol. 2: 186
CA-10	Peña Harpada	White limestone	Madoz 1845, Vol. 1: 376
SE-3	Lora de Estepa	Coarse limestone	Madoz 1847, Vol. 7: 690
SE-5	Alanís	Undetermined	Madoz 1845, Vol. 1: 190
HU-6	Zalamea la Real	Granite	Madoz 1850, Vol. 16: 450
CR-3	Chillón	Granite	Madoz 1847, Vol. 7: 327
GU-6	Corduente	Granite	Madoz 1847, Vol. 7: 9
GU-7	Castilnuevo	Limestone tufa	Madoz 1847, Vol. 6: 172
AB-1	Fuentealbilla	White limestone	Madoz 1845, Vol. 1: 51, 256
BA-4	Salvaleón	White limestone	Madoz 1849, Vol. 13: 711
BA-5	Jerez de los Caballeros	Granite	Madoz 1847, Vol. 9: 627
CC-4	Bohonal de Ibor	Granite	Madoz 1846, Vol. 4: 376
CC-6	Logrosan	Granite	Madoz 1847, Vol.10: 355
M-3	Comenar Viejo	Granite	Madoz 1847, Vol. 6: 530
SE-7	Gerena	Granite	Madoz 1847, Vol. 8: 348
GU-5	Tobes	Limestone tufa	Castel 1881: 158

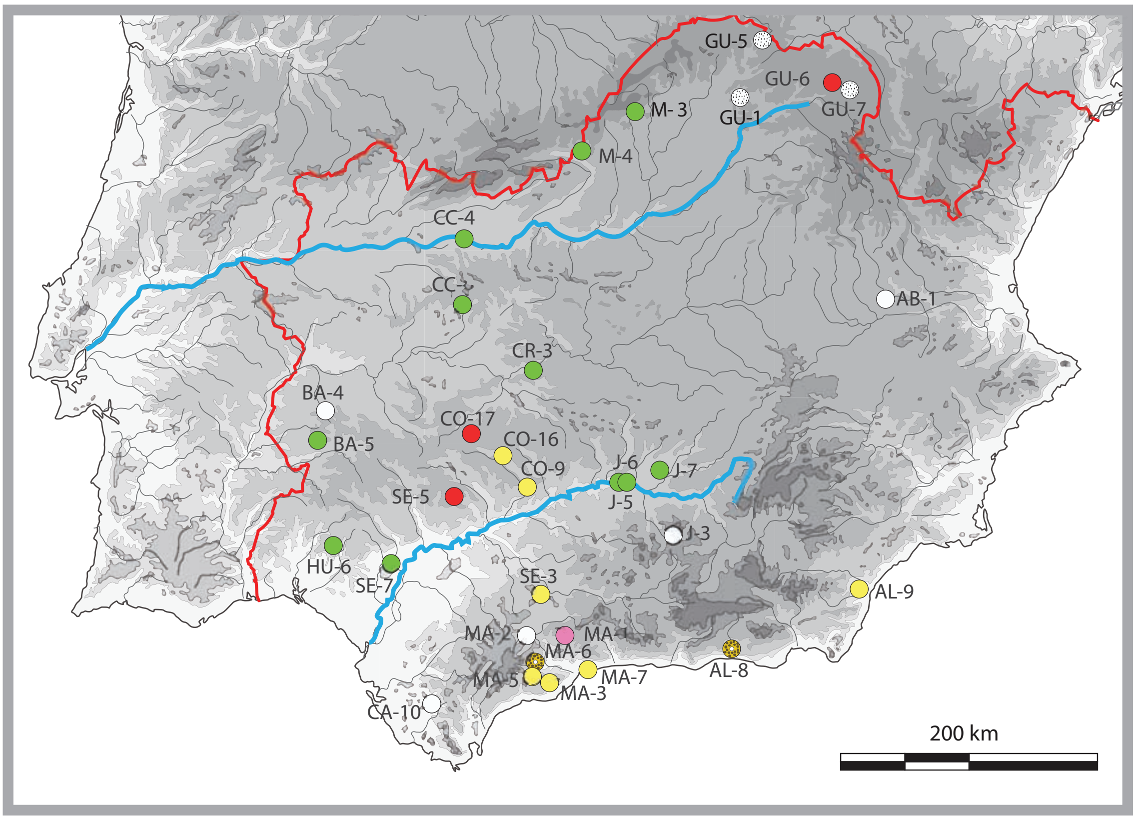


Fig. 12.26: Map of Contemporary "local" millstone quarries with no evidence of distribution over a range of about 20 km.

12.7.5. Interpreting the distribution of Contemporary millstones

The map illustrating the spread in Contemporary times of millstone quarries by their category of distribution potential and their rock type in the southern half of Spain can be divided into three main zones based on density of site and petrography (fig. 12.27).

Zone 1

The first zone, south of the Guadalquivir River Basin, covers much of Andalusia, from the Bay of Cádiz to the Sierra Nevada in Granada and tapers off in the Province of Almería. This corresponds to a large portion of the Bétic geological range. Here, there is an important density of millstone quarries exploiting sedimentary stones.

The dominant stones in this period are hard, fine white and rose limestones with outcrops from Cádiz to Granada and important productions starting at Berrueco (CA-8), Los Frailes, Cabra (CO-1) in Córdoba and Moclín (GR-1) in Granada. These sites were complemented by similar productions at Alhama de Granada (GR-6), Loja (GR-2/3) and Vélez de Benaudalla (GR- 10). These are all sites exploiting rocks that reputedly yielded a white flour.

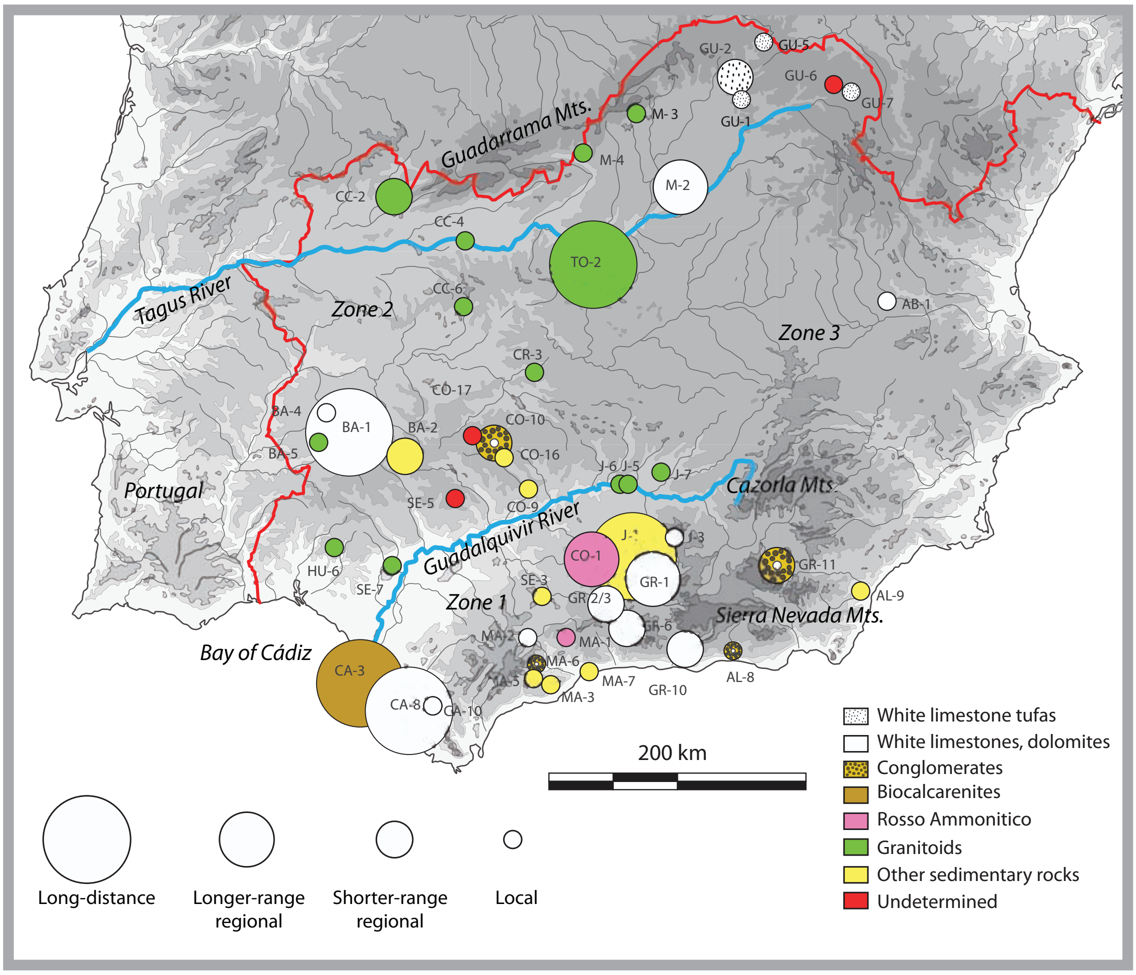


Fig. 12.27: Map combining the spread of the four classes of millstone quarries from Contemporary times (late 18th to early 20th centuries) according to their spheres of distribution and rock types.

The potentially important site of Castillo de Locubín (J-1), with a sample exhibited in the Universal Exhibition of Paris in 1867, is difficult to explain. Its coarse yellowish texture would not seem to be as efficient in milling as the rock of the nearby site of Moclín. The field survey, however, indicates a large production. The density decreases to the east. The site of Caniles (GR-11) was exploiting a conglomerate with large rounded clasts for, in the words of Madoz, "brown bread".

The long range production of ostionera stone is also difficult to explain and could be anomalous. The only site of this type was Rota (CA-3), where millstones were extracted for transport to Portugal. This stone may have been destined for grinding a different type of product because for cereal grinding, the nearby Berrueco quarry (CA-8), with its white limestone, dominated this area.

Zone 2

The second zone stretches from the north of the Guadalquivir River, from the Cazorla Mountains of Jaén, to the northern Bay of Cádiz, to the Portuguese border, to the Sierra de Guadarrama in the north from Cáceres Province to Guadalajara, passing through Madrid. This encompasses much of the western Iberian Massif and the Ossa Morena and South Portuguese geological zones.

This zone is dominated by granitoids in the form of vast extensive outcrops and rounded surface boulders. The site of Ventas de Peña Aguilera (TO-2), a certified millstone producer and exporter since the 16th century, is its major exponent (Viñas & Paz 1951: 216; Baltanas 1998: 36-37). A series of smaller granite sites, from the Guadalquivir Valley to the north of the Province of Cáceres, complete the granite spread.

Inside the granite-dominated zones, there are four pockets of sedimentary productions, three of which are presumably important. Alconera (BA-1) to the south in the Province of Badajoz was making millstones that yielded a white flour for white bread (Caso Amador 2008: 132-133). The fact that it sent millstones to the Universal Exhibition of Paris in 1867 (Comisión Régia 1867: 182) suggests its products had a high reputation and that it was trading its millstones over a wide area.

A second pocket is the production of Colmenar de Oreja (M-2) that supplied the *tahonas* of the city of Madrid, probably a large market, considering the lack of a main river crossing the city. It is interesting that in spite of the availability of granite from scores of closer nearby quarries, the animal-driven flour mills chose the Colmenar de Oreja limestone, reputed to yield a white flour for white bread (Vallejo 1833: 387).

The third pocket, exploiting the porous limestone tufa, is represented by the quarry of Brihuega (GU-1) in the Province of Guadalajara. This site is also noted for millstones that yielded a very white flour, as white as that of Colmenar de Oreja (Vallejo 1833: 387). There is also what appears to be a more modest production of quarries in Guadalajara, on the northern fringe of the area. The pocket is completed by the smaller limestone tufa workings at Pinilla de Jadraque (GU-2) and Tobes (GU-5) by Sienes.

A fourth pocket is in the south of the zone, in the Sierra Morena, and is made up of a series of sedimentary stone exploitations, with its major exponents being first the quarry along the Albardado stream (CO-10) near Belmez, Cordoba, a conglomerate outcrop with large rounded clasts (a sort of puddingstone) and, secondly, Llerena (BA-2) of an unidentified sedimentary stone. We fail to see that the quality of these millstones was superior to that of the dominant granite sites. In any case, production of this group was not widespread and probably not relevant outside a local sphere.

Zone 3

The third zone is a vast "no man's land" covering the eastern half of the Iberian Massif. It stretches from the north of the Province of Jaén, through the Autonomies of Murcia and Valencia, and large parts of the Provinces of Albacete, Cuenca, Toledo and Ciudad Real. The sole millstone quarry documented in this area by the 19th-century geographers is the site Fuentealbilla (AB-1) in the Province of Albacete. It is a site known since the middle of the 18th century by the Census of the Marqués de Ensenada and certified in the 19th century by Madoz (1845, Vol. 1: 256)

We ignore the reason for this huge absence of sites. Since their identification is based principally on 19th-century geographical studies that applied a systematic means of collection of information throughout Spain, the large gap is surely not due to a lack of rigour on behalf of the Madoz and his collaborators. The gap could be related to geology. Quaternary and soft Tertiary material, usually too soft for millstones, abound in the zone. However, in this vast zone the absence of suitable rocks would be astonishing. One possible explanation, totally hypothetical, is that the mills in these regions relied on small, anonymous quarries that did not merit the attention of the 19th-centuries geographers.

For the more important watermills, windmills and *tahonas* of this zone, we submit the hypothesis that they could have been supplied by millstones imported from the Montjuïc quarry of Barcelona. It is well known that the Montjuïc exported its products long distances in the Mediterranean (France, possibly Italy) and along the Catalonian coast as far south as Murcia (Español 2009: 967 Barberá Miralles 2003: 194). This quarry certainly supplied the coastal cities of Valencia, Castellón and Alicante. For the inland mills it is less certain. A clue comes from the quarry of Fuentealbilla (AB-1), the only certified Contemporary production in the zone. Madoz ,comparing the Fuentealbilla millstones to those of the Montjuïc asserts the following:

"... y en le Molar, térm. de Fuente-albilla, del mismo part., la de piedras de molínos, de grano poco compacto, por lo que se aprecia menos que la barcelonesa" (Madoz 1845, Vol. 1: 256), which translates roughly as follows: "... and at the place name Molar, in the area of Fuente-albilla, there is a millstone quarry with a stone that is not very compact, that is less valued than that of Barcelona".

We can therefore infer from this comparison that the "Barcelona" stone was present in the area and, along with the geological arguments, may explain the scarcity of millstone quarries in this area.

The long-distance exports up and down the Mediterranean coast from the Montjuïc of Barcelona, the Iberian exploitation with the widest certified commercial reach, was a precursor of a phenomenon that was soon to shake the foundations of the Iberian millstone industry. This phenomenon was the introduction from France of siliceous, "intelligent" millstones, the famous *meulas francesas*, responsible for yielding a fine, white flour for a bread called "the best of breads" (Belmont 2006, Vol. 2: 148-153). This industry, in expansion for several centuries, was progressively gaining a stronghold throughout Europe since the end of the 18th century (Belmont 2006, Vol. 2: 132-134). Its arrival on a large scale in Spain would take place after the after the Industrial Revolution in the mid-19th century, shortly after the publication of the Madoz dictionary (1845-1850) and, in part, as a result of the construction of a nationwide railway network century (Reyes Mesa 2000: 3). French Burrs were omnipresent in mills throughout the Spanish landscape. It must be noted that the *meulas francesas* are mentioned in practically every article about Spanish watermills published in the last decade. Their introduction would, in any case, provoke the demise of the Spanish millstone quarry industry.

13. FROM STONE TO BREAD

The process of grinding, sieving and baking bread is complex and entails many variables that changed through time, depending on the type of product (wheat, barley, rye, millet) (Rodríguez Monteoliva 1989: 684-685), the type of stone and the milling technology. In this brief chapter, our intention is not to examine this process in detail, a subject that is well beyond our scope, but to focus on two aspects related directly to quarries and millstones. The first is the abrasive grit released into the flour during grinding that had an adverse effect on teeth (hence the health) of the population. A second question, linked to the first, is the aspiration, appearing presumably in Late Medieval times, to make a white bread, free of "impurities".

13.1. Grit in the bread

Grit in the bread resulted, first of all, from milling cereals that were not previously cleaned. Agustí, in a chapter on the secrets of milling wheat and making bread of his treatise on agriculture dating to 1722, underscored the importance of washing the grains before grinding, because unwashed grains released pernicious dust and other impurities into the flour (Agustí 1722: 187).

It was the stones, however, that were the major culprits of tainting the bread. Gómez Ruíz, in his study of watermills along the Odiel River in Huelva, cites a Municipal Archive of Aroche dating to 1574 that refers to this problem. The document records that the *Cabildo* (church authorities in this case) ordered "*granno*" millstones to be coupled with "*concha*" millstones because the flour from "*concha*" stones was "harmful" (Gómez Ruíz 2003: 31). Gómez Ruíz interprets the *granno* as granite upper stones, *granno* referring to the dark "specks" of white biotite in the rock. *Concha* (shell) millstones, on the other hand, were less compact, darker-coloured, lower stones with shell fragments. The choice of granite for the upper stones is not surprising since Aroche is in a granite district with a millstone quarry located at the Fuente de Aliseda (HU-7) (de Dios Ayuda 1794: 348). In any case, the historical record not only reveals concern by the authorities for the health of its citizens, but establishes a solution to remedy the problem. The record, however, does not shed light on the type of ailment the bread produced. It is reasonable, nonetheless, to suppose that it was related to the teeth.

Agustí, alluded to previously, stressed that the millstones must be "*fuerte*" (strong, meaning hard) and not "*blandos*" (soft), because the softer stones release "*polvo*" (dust) into the flour (Agustí 1722: 186). Agustí also noted that stone grit found its way into the flour especially during the first round of milling after a millstone's "*picada*" (dressing) (Agustí 1722: 187). In the Alpujarra mountains of Almería, a technique to rid the stones of these impurities resulting from dressing was to run sawdust through the stones. This practice at times led to conflict with the farmers, who mistakenly believed that the grains they entrusted the miller were being sacrificed to clean his stones (Cara Barrionuevo *et al.* 1999: 153).

Grit in the bread certainly had a pernicious affect on the population of southern Spain and was heightened by the necessity of millstones to be dressed frequently, in certain cases on a daily basis, thus raising the amount of dust finding their way into the bread. There are records that indicate that the stones from Colmenar de Oreja (M-2) required dressing after every six hours of work (Vallejo 1833: 387). Millstones in the Alpujarra Mountains of Granada and in Jaén also had to be dressed daily (Ordoñez 1993: 3; López & Cabrera 2004: 204). We ignore if the grit of certain stones was more harmful than that of others. In any case, the problem practically disappeared in the 19th century with the introduction of the hard siliceous stones from France, stones that only required a minimum of dressing.

13.2. White and dark rocks, millstones and bread

In our study area there are a series of terms or expressions associated with quarries, millstones, flour and bread that have multiple interrelated meanings that are, at times, difficult to interpret. *Piedra blanca*, for example, in its general sense, denotes a white-coloured stone exploited in a white-stone quarry. But it also designates the upper stone (runner) of a millstone pair. *Bazo or baza,* meaning dark, and *baxo,* meaning lower, denotes both dark-coloured stones, as well as the lower stone of a millstone pair. The adjectives *blanco* and *bazo*, in milling terminology, designate the colour and type of flour, hence the colour and type of bread. *Pan blanco*, therefore, is white bread, whereas *pan bazo (or baxo)* denotes dark bread. The connotations of these colours go beyond simple definitions of stones, quarries, flour and bread and have social and economic implications.

13.2.1. White and dark millstone rocks and quarries

The Berruecos Mountain (CA-8) in Cádiz was a "... mine of white, grainy stone exploited for mills and animal-driven flour mills" (Martínez y Delgado 1875: 129). Similarly, Salvaleon (BA-4) in Badajoz was also described as a "white" exploitation (Madoz 1949, Vol. 13: 711). The rock of El Hacho in Seville (SE-3) was "rough and white and apt for flour mills" (Madoz 1847, Vol, 7: 609). Around Loja (GR-2/3), Granada, there were also "white" stone quarries (Madoz 1847, Vol. 10: 360). The petrography of the preceding exploitations, from what we have gathered by field surveys and from geological maps, varies from limestone to dolomites, rock types that are white.

On the other side of the colour spectrum are the quarries exploiting coarse, dark-coloured rocks. Tomás López, in the late 18th century, mentions the "*piedras bazas*" from Otívar (GR-13), in the southern mountains of Granada (Reyes Mesa 2000). García de la Leña also uses "*bazo*" for the quarry by the Jabonero Valley (MA-7) (García de la Leña 1789:106). We have not been able to inspect these sites, but from what we can gather, the Jabonero was a coarse limestone and Otívar was probably conglomerate.

Jerez de los Caballeros (BA-5) in Badajoz is unique in that it is the only location where flour millstone quarries were both white and dark (*"... hay tambien canteras de piedras morena y blanca para molinos harineros ..."* Madoz 1847, Vol. 9: 627). We do not know if this is an allusion to the exploitation of different types of rocks in this predominantly granite area (granites and limestones, for example) or if it connotes different qualities of granite.

In any case it appears that white stones were not as hard as dark stones, and inside the same categories of rock type, for example limestones and granites, there were great differences of quality. A miller of the Alpujarras recalls that white stones could grind about 12 *fanegas* (bushes) of flour (c. 600 kg) before dressing, whereas dark millstones could grind ten times the quantity (120 *fanegas*) (Cara Barrionuevo *et al.* 1999: 155). If these proportions can be extended more generally to white rocks, such as fine limestones and dolomites, and dark rocks such as coarse limestones, conglomerates and sandstones, then we can wonder why millstone makers bothered to exploit white rocks, if it were not other properties they possessed, such as yielding a white flour.

13.2.2. "White" upper stones and "*baza*" lower stones

A second definition of the term "*piedra blanca*" (white stone) designates the upper stone (runner), whereas "*piedra baza*" (coarse stone) and "*piedra bermeja*" (reddish stone) designates the lower stone. These names appear in a number of historical archives throughout Andalusia from the 15th through the 19th centuries (Córdoba de la Llave 1988: 842-843, 853-854, 871, footnotes 24, 62, 68, 137; López & Martín-Caro 1989: 1022; Gómez Ruíz 2003: 31; Córdoba de la Llave & Varela 2010: 148, 183; Rodríguez Monteoliva 1989: 705).

The origin of these names is not defined in the molinological literature. It is plausible that they come from the use of finer "white" stones (limestones) for runners, and coarser, darker or "reddish" stones (sandstones and conglomerates) for lower stones. The Municipal Archives of Aroche (Huelva) from 1574, alluded to previously (Gómez Ruíz 2003: 31), corroborate the use of two different rock types for millstone pairs, such as a granite runner (white biotite) coupled with a coarse limestone lower stone. There is probably a link between these terms and rock types because there is evidence that certain quarries produced only upper stones, whereas others only made lower stones. Hornachuelos (CO-13), for example, only supplied upper stones, while Albaida (CO-7) was specialised in lower stones (Córdoba de la Llave 2003: 305). The problem of these two Córdoba sites is that their geological definitions are identical (limestone or dolomite) so each should fall roughly into the category of "white" quarry. In spite of the geological similarities, it is highly likely that the rocks of these two sites, though geologically similar, possessed different grinding properties, as is the case of El Berrueco (CA-8) and La Pila de Casares (CA-12) near Medina Sidonia that will be elaborated later in this chapter.

13.2.3. Dark and white bread millstone quarries

Since the Middle Ages, the colour of bread has been associated with the "power and refinement" of the upper classes (Belmont *et al.* 2011: 221-223). In our study area, as a consequence of centuries of Islamic rule, we cannot help but evoke the symbolism at the beginning of the 16th century of a whiter bread linked to the Christian Reconquest. We are tempted to speculate that the desire for an ever whiter bread ran parallel to the desire of the Catholic rulers to maintain a pure and orthodox faith, symbolised by the pure white eucharistic body of Christ, untainted by impure elements from the *conversos*, converts to Christianity from Islam and Judaism.

The role of millstone quarries in attaining a fine, white flour for a soft, white bread is a subject that A. Belmont has been investigating in the last years in France through historical texts and petrographical analyses undertaken in the framework of archaeological excavations (Belmont 2006: 86-89; Belmont 2011: 14-16).

In our study area we also find, as would be expected, that white bread was reserved for the upper classes and dark bread for the poor. For instance, in a sermon in 1558, the Dominican Friar Domingo Baltanás of Seville recorded how "*gran señores*" (nobles) shared their food. The sermon relates that elderly members in the service of nobles, who had been at their side in times of war and peace, ate from the same plate as the nobles. The poor, due to their condition, also received food, but not the "*pan blanco*" (white bread) from the noble's table, but "*pa baço y duro"* (hard, dark bread) (fig. 13.1).

Dictionaries and religious writings throughout the 17th century record the multiplication of the use of the terms "*pan blanco*" and "*pan bazo*".

This white/dark dichotomy was also reflected in the colour of the bread obtained, or reputedly obtained, from certain millstones. An early reference (1776) to the role of the millstones in making white flour comes from Zubieta, Navarra in a notarial protocol that records that the stones of a watermill were worn and were yielding a "dark and rough" flour, causing the mill, owned by the authorities, to lose clientele and revenue. The document therefore advises that the stones be replaced with a new pair from Macaia, France (i.e. Labort region), stones known to yield a whiter and softer bread (Alegría Suescun 2007: 8, footnote 15; AGN, Sección de Protocolos Notariales. Notaría de Santesteban, año 1776, c. 125, 140). We ignore the petrography and the exact source of the Macaia stones (siliceous stones from Dordogne?). In any case, the archive demonstrates that 18th-century mill owners were willing to go beyond their local quarries and import superior millstones that yielded white flour.

It is obviously not the stone *per se* that produced a soft, white flour. An array of factors played a role in the quality and colour of the daily bread. The choice of cereal, to begin with, was fundamental. Of the available cereals, bread wheat, with its starchy endosperm, was the more commonly accessible white bread grain (Lagardère 1991: 64-65). Other grains such as rye and barley, by contrast, served for darker bread.

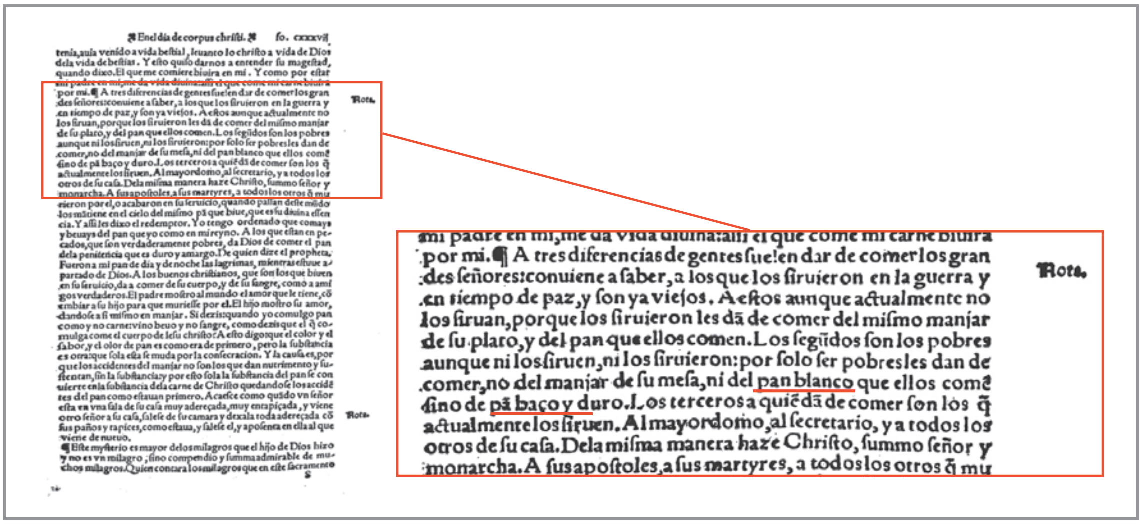

por mi. ¶ A tres diferencias de gentes suelen dar de comer los gran
des señores: conuiene a saber, a los que los siruieron en la guerra y
en tiempo de paz, y son ya viejos. A estos aunque actualmente no
los siruan, porque los siruieron les dã de comer del mismo manjar
de su plato, y del pan que ellos comen. Los segũdos son los pobres
aunque ni los siruen, ni los siruieron: por solo ser pobres les dan de
comer, no del manjar de su mesa, ni del pan blanco que ellos comẽ
sino de pã baço y duro. Los terceros a quiẽ dã de comer son los q̃
actualmente los siruen. Al mayordomo, al secretario, y a todos los
otros de su casa. De la misma manera haze Christo, summo señor y
monarcha. A sus apostoles, a sus martyres, a todos los otros q̃ mu

Fig. 13.1: Extract of a sermon of the Dominican Friar Domingo Baltanás from Seville. In the text we find both the terms "pan blanco" and "pan bazo" (written "pa baço") (from the Exposicion de los Evangelios con sermones desde primero domingo del Aduiento hasta el domingo XXV despues de la trinidad, sacada de los sanctos doctores la yglesia by Domingo Baltanás, folio cxxxvi. 1558; from Google Books). Interpreted transcription: "A tres diferencias de gentes suelen dar de comer los gran señores: conviene a saber, a los que los sirvieron en la guerra y en tiempo de paz, y son ya viejos. A estos aunque actualmente no los sirvan, porque los sivieron les da de comer del mismo plato que ellos comen. Los segundos son los pobres aunque ni los sirven, ni los sirvieron: por solo ser pobres les dan de comer, no de manjar de su mesa, ni del pan blanco que ellos comen sino de pan baço y duro. Los terceros a quien dan de comer son lo que actualmente los sirven. Al mayordomo, al secretario, y a todos los otros de su casa."

A fundamental factor in the obtention of white bread was the miller's technical ability. The miller determined the quantity of water to add to the grains previous to grinding to facilitate the separation of the bran from the white endosperm. The Catalonian writer Agustí noted, for example, that adding salt to the water to humidify the grain before milling resulted in a whiter flour (Agustí 1722: 187).

The miller also controlled the amount of "light" left between the upper and lower millstones so as to ensure a coarser or finer grinding. He also decided when to accelerate or slow down the rotation of the stones, and when to halt grinding to remove and re-sharpen the stones. Finally, the miller determined if the flour needed a second round of grinding, and the choice of the sieves to attain the desired calibre of flour.

In spite of all his skill and experience, he could not attain white flour without the proper millstones. One of the advantages of the bright white stones from the limestone quarry of Claix, near Angoulême in southwestern France, was that the powder it released into the flour was invisible to the eye and did not affect the flour's colour; dark grit from conglomerates, granites or sandstone, by contrast, did tint the bread (Belmont 2011: 15). In sum, the advantage of grinding with certain white rocks was not the absence of stone residue in the flour, but the perception of its absence.

In his research on the watermills of the Alpujarra Mountains south of Granada from the 15th-18th centuries, Rodríguez Monteoliva directly associates "*piedra blanca*" with "*pan blanco*" and "*piedra baza*" with "*pan bazo*". Accordingly, the stone was not called "*bazo*" because of its brownish or yellowish colour, but due to the colour of the flour that it yielded. This colour, according to the writer, was due to the particles of bran that could not be separated by even the finest sieve (Rodríguez Monteoliva 1989: 701).

Unfortunately, in the case of the Alpujarra Mountains, we cannot associate the types of bread with specific quarries. The few sites there appear to be coarse stones, most likely conglomerates with large clasts. It is probably for this reason that "white stones" had to be imported from Moclín (GR-1), at least 50 km away (Rodríguez Monteoliva 1989: 705).

In our study area, several millstone quarries are directly or indirectly linked with white bread though old written texts (fig. 13.2). The Survey of 1791 of Extremadura, records that the Alconera (BA-1) rock in the Province of Badajoz is a "*concha*" (shell) stone exploited for flour mills that yield "*pan blanco*" (white bread) (Caso Amador 2008: 133). From what we can gather through

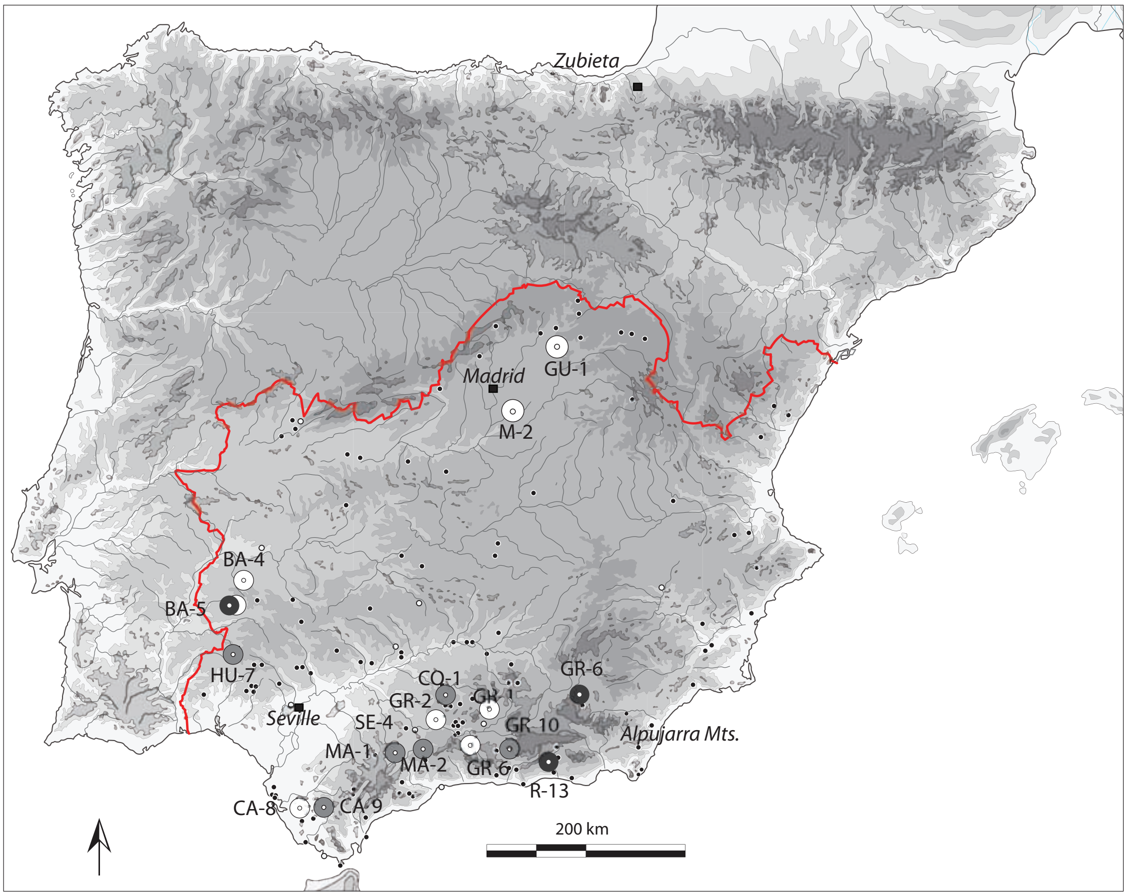


Fig. 13.2: Map of the sites and regions mentioned in this chapter. Sites designated as "white" quarries in texts (in white): Colmenar de Oreja (M-2); Berruecos (CA-8); Salvaleon (BA-4); El Hacho (SE-3); Loja (GR-2); Moclín (GR-1); Alconera (BA-1); Alhama de Granada (GR-6); Brihuega (GU-1); El Berrueco (CA-8). Sites designated as "dark" quarries in texts (in black): Otívar (GR-13); Jabonero (MA-7); Caniles (GR-6). Jerez de los Caballeros (BA-5), according to texts, has both white and dark quarries in its surroundings. The sites in grey are presumably "white" quarries: Fuente de Aliseda (HU-7); La Pila de Casares (CA-12); Teba (MA-2); El Torcal (MA-1); Los Frailes, Cabra (CO-2); and Vélez de Benaudalla (GR-10).

geological sources (Geological map 854, *IGME*), the Alconera rock is a limestone that must have had superior grinding properties because its millstones were exhibited in the Universal Exposition of Paris in 1867 (*Catálogo Exposición Universal* 1867: 182, entry 13-57). The Fuente de los Morales quarry by Alhama de Granada (GR-6), with its specific layer of hard white rock produced, according to Madoz, "... *las mejores muelas de molino para pan blanco*" ("... the best millstones for white bread"). These were commercialised throughout the region, even through the mountains into the Province of Málaga (Madoz 1847, Vol. 8: 216), a distance of approximately 20 to 30 kilometres.

Two other quarries associated with white bread are Brihuega in Guadalajara (GU-1) and Colmenar de Oreja in Madrid (M-2). A 19th-century treatise on hydraulic power records that millstones from Brihuega produced "... *una harina tan blanca como la de Colmerar*" (a flour as white as that of Colmenar). This reference likens Brihuega's white "pumice" millstone production with that of white limestone at Colmenar de Oreja, a site known for supplying stones to the animal-driven flour mills of Madrid (Vallejo 1833: 387).

The comparison of the grinding qualities of the limestone quarries of El Berrueco (CA-8) and La Pila de Casares (CA-12) by the priest of Medina Sidonia (Cádiz) toward the middle of the 18th century shows that there could be differences in the colour of bread, in spite of the similarity of their rocks. The rock at the Pila de Casares, "... *no es tan blanca como la de Berrueco, pero es más cortante y muele mejor… y porque aunque saca más harina de igual porción de trigo, sale prieta y queda el pan algo moreno* ..." ("... is not a white as that of Berrueco, but cuts and grinds better ... and although more flour yielded from the same amount of wheat, it comes out darker and the bread is somewhat darker ...") (Martínez y Delgado 1875:129). From the geological maps the rocks of these two sites are identical. But the text clearly indicates that the Berrueco site (CA-8), probably the largest and longest production site in the Province of Cádiz, delivered millstones that yielded a flour superior to those scored at La Pila de Casares (CA-12).

There are other sites not confirmed in texts that we would consider, based on our field observations, as potentially "white quarries". Teba (MA-2) and Vélez de Benaudalla (GR-10) share bright white, homogeneous stones. There are also rose-coloured stones near Loja (Madoz 1847, Vol, 7: 609), as well as r*osso ammonitico* limestones at El Torcal (MA-1) and Los Frailes near Cabra (CO-2) that surely would not have gained their high reputation and large production if they did not share the same grinding properties as their "white" quarry counterparts.

Opposed to the "white quarries" are those directly linked to dark bread. Tomás López, in his 18th-century *Diccionario Geográfico*, points out Otívar (GR-13) as a "*piedra basa*" (*basa* stone) quarry (Reyes Mesa 2000b: 2-3). Reyes Mesa notes that historians have interpreted "*baxo*" (or "*baso*") bread in historical records, dating as far back as the 16th and 17th centuries, as a sort of low, unleavened flat bread when, in fact, it is bread made with "*harina baxa*" (*baxa* flour) from dark, coarse "*piedras baxas*" (*baxa* stones). The author explains that the bran was not separated by these coarse "*baxa*" millstones resulting in a rough bread with a darkish tint, similar to the colour of the stones. The name given to the bread, therefore, comes from the name of the stone (Reyes Mesa 2000b: 2-3). From what we have been able to gather, it is likely that a large part of these "dark bread" quarries were in fact conglomerates (puddingstones) containing rounded pebbles.

In any case this is certainly the case of the Rambla de las Canteras conglomerate (pudding-stone(quarry outside of Caniles (GR-6). Madoz is brief but succinct when describing it: "... *hay una cantera de piedras de molino para pan moreno*" ("... there is a millstone quarry for dark bread") (Madoz 1846, Vol. 5: 461).

From these different labels given to quarries, we perceive that there are tendencies between the colour of the rock and the colour of the bread. This is, however, a highly simplistic view. It is reasonable to suppose that coarse limestones, sandstones and conglomerates resulted in a dark bread, not so much from the grit they released into the flower, but from their lesser ability to separate the bran from the endosperm. Hard white limestones, by contrast, appear to be more apt to separate the bran from the endosperm and therefore yield a whiter flour. In addition, the fine white grit released into the flour was probably invisible to the eye.

However, as seen from the sites of Berrueco (CA-8) and Pila de Casares (CA-9) in Cádiz, there were certainly different slight differences of properties inside the same lithography. An identical rock, at least from the macroscopic point of view, can therefore yield two different types of bread. These issues, still not adequately answered, would certainly benefit from future research incorporating petrographical analyses. Another factor to take into account on this subject is that the conception of white bread has probably changed through time. A white 16th-century bread might not be considered a white bread in the 19th century. These are further questions that remain to be explored.

In any case a revolution in bread making took place in southern Spain with the introduction of French siliceous millstones in the second half of the 19th century. These new "intelligent" stones rendered the white limestone millstones "obsolete" and progressively provoked the end of the millstone quarry industry. It may not have been so much the French siliceous stone's ability to produce white flour, but the fact that French millstones did not require the long hours of dressing, often on a daily basis, that the white limestone millstones demanded. French millstones, dressed only every few months, therefore permitted longer, uninterrupted hours of milling, enhancing dramatically the quantity of production of high quality white flour and raising the affluence and status of millers while obliging millstone makers to seek employment in other sectors of the rock industry.

14. CONCLUSIONS AND PERSPECTIVES

This general conclusion is meant to summarise not only the contents and conclusions developed in the individual chapters, but, at times, to go beyond and convey more general reflections. So as to facilitate consultation of the details of the individual chapters, this conclusion is structured following the order of the chapters. It also serves as the base for the translation into French of the main ideas developed throughout the study.

14.1. Introduction

The opening assertion in the introductory chapter that millstone quarries are "everywhere" is, of course, an overstatement to convey the notion that these exploitations are much more numerous throughout the landscape of southern Spain (and Europe) than has been commonly recognised. From the considerable molinological research in our study area of the last two decades, focused principally on the features and mechanics of watermills and rarely on the question of millstones themselves, we do not have the impression that they are widespread. But in fact, they are very common, except in regions with unfavourable geological formations, such as large river basins filled in by alluvial deposits and large extensions of soft or brittle rocks. To wit, the quantity of millstone quarries identified in southern Spain since the outset of our research has increased from a number that could be counted on one hand to more than a hundred.

We have also attempted to note throughout this work, that millstone quarries and their products played an essential role in the operational sequence of grinding cereals, the base of the nutrition of the people, on at least an equal par with cultivating, harvesting and storing grain for human consumption. They also were essential to the olive oil industry and metal working.

We have also drawn attention to the problem of identifying these sites. It is not always simple, for example, to differentiate a millstone quarry from a site that produced similar cylinders employing identical extraction techniques (columns, sharpening stones, olive grinders). To bring this point home, we have included in our catalogue the Roman construction quarries of Cerro Bellido, Seville (SE-4) and Punta Camarinal/Punta Paloma, Cádiz (CA-2a-b)produced "drums" that out of context could be taken for millstone roughouts. In both of these cases their inclusion in our catalogue is appropriate because there is evidence (although weak) that these Roman drums were at a later time recycled into millstones. This problem of identifying these sites, especially those that do not benefit from written texts, is particularly relevant in the south of Spain due to the presence of the large production of cylindrical rollers for olive oil *almazaras*, a huge industry in the south of the Iberian Peninsula.

14. 2. Sources, resources and fieldwork

Of all of the different sources available to identify millstone quarries, the most valuable are those of geographical dictionaries and other writings dating from the end of the 18th century to about the middle of the 19th century. The works at the national scale of S. Miñano (1826-1829) and P. Madoz (1845-1850), and their collaborators, account for the largest number of sites presented in this study (slightly less than half). It must be noted that the group pointed out by Madoz (about 40) is much larger than that of Miñano (5). We have nonetheless insisted on repeatedly mentioning Miñano to advise future researchers of the validity of his contribution that is more focused, from the point of view of millstone quarries, on the north of Spain, outside our study area. Other works of regional character, such as the histories of García de la Leña (1789) for Málaga, and that of Martínez y Delgado (1875) for Medina Sidonia, Cádiz, as well as a few early geological works such as that of Ezquerra del Bayo (1856), also offer relevant data.

All in all, these sources account for almost half of the sites we have been able to identify. Nonetheless, in spite their significance to our research, they serve little more than to identify the municipality of a site and rarely offer more than a modest vignette into a site's production. In this sense they serve as starting blocks from which to initiate research.

As elsewhere in Europe, notably in France, historical sources such as Royal Decrees, Municipal Ordinances or notarial protocols also identify millstone productions, and at times provide data, although usually very limited, related to the distances of commercialisation, means of transport and diameter of millstones. These documents are also especially relevant in establishing the chronology of a certain number of sites before the advent of geographical and geological treatises mentioned above, after the fall of Islamic rule, from the Late Middle Ages to Modern times.

It must be noted that in the course of our research, these types of historical archives were barely exploited as primary sources, a task beyond our means that would have required weeks or even months in local archives sifting through old documents and deciphering the old Castilian calligraphy. The primary sources that we have quoted, except a few that are available over the internet or in the form of DVDs, are from molinological research undertaken by historians. Noteworthy is the work of the medievalist Córdoba de la Llave on watermills in the city and province of Córdoba.

Having said that, a large number of private, national, provincial and municipal historical archives are still waiting to be exploited from the perspective of millstone production. The private records of the aristocratic family of the Duque de Medina Sidonia in San Lúcar de Barrameda, Cádiz, for example, will certainly shed light on the vast millstone production of El Berrueco (CA-8), a quarry that the family counted among its possessions for at least several centuries. The Duque de Medina Sidonia archives will also, without a doubt, elucidate the relationship between the Berrueco workings and a number of watermills owned by the family, such as those in the town of Vejer de la Frontera. A writer in 1813, recorded that the Duque was remunerated with 18 millstones a year for the concession at Berruecos millstones (Cruz y Bahamonde 1813: 91, note 1). We are left with the idea that millstones were more interesting than currency for the Duque because they could have served to replace the millstones of the watermills he owned.

In the few years that have passed since the beginning of this study, the access to written sources, from old geographical dictionaries to molinological articles, has soared. When we initiated our study, for example, only a few of the volumes of the Madoz dictionary were only partially available over the internet in a format that could be searched by means of optical character recognition (OCR). Therefore, at that time we were required to read a number of volumes between 700 and 1000 pages each, word for word, searching for even the most remote allusion to millstone workings. This initial reading of the texts, an extremely onerous task, nonetheless furnished insight both into the way these millstone quarries were recorded and understanding the contexts of the sites subsequently identified by searches by OCR text recognition.

This research of historical texts required developing certain skills of a historian. As an archaeologist, I was obviously more comfortable in museum depositories. In any case, the two procedures went hand in hand regarding the subject of millstone quarries, because on the whole, the first provides insight into Modern and Contemporary productions, whereas the second provides data for the older production centres, from Protohistory to Antiquity.

The information gleaned from studying millstones stored in museum collections not only served to establish an initial general classification of querns and millstones (the products of the quarries), but also served to identify a number of production centres and districts. The 40 *ostionera* querns at the Roman city of *Baelo Claudia*, as opposed to a single volcanic import, clearly demonstrated the exploitation of the *ostionera* rock, with outcrops found exclusively along the coastline of the Bay of Cádiz. Moreover, numerous volcanic stones among the large collection at the *Museo Arqueológico de la Provincia de Murcia*, suggested exploitations of local and regional volcanic quarries, whereas the majority of granite millstones at the *Museo Nacional de Arte Romano* in Mérida, is evidence of local and regional granite exploitations.

Millstones in museums, at times can point to specific millstone production centres. The unfinished and broken lamproite querns in Murcia, collected from the Municipality of Mazarrón, can be traced back to a lamproite outcrop at the Cabezo de la Oliva (MU-2), a short distance from the Roman villa where they were discovered. Likewise, a second set of roughouts in the Museum of Almería, also point to the quarries of the Cabo de Gata that have been confirmed in the field (AL-1 and AL-2).

Although written sources and museum depositories are a wealthy source of information about millstone quarries, they are limited almost exclusively to the chronological frameworks ranging respectively from Prehistory to Antiquity and from the end of the Middle Age to the 19th century. They provide little data about the Middle Ages, from the Gothic domination through the end of Islamic rule. This shortcoming will be felt throughout this study.

A third source of information about millstone quarries, labelled "unconventional", has proven to be extremely useful to identify a great number of sites. As we have noted in chapter 8 about quarry infrastructure, millstone production sites were often served by tracks, paths or roads, some of which have endured and are now integrated into hiking trails. Hence a number of millstone workings have been identified as a result of consulting a growing number of hiking itineraries posted on the internet, often accompanied with descriptions of the landscapes and photographs of the different "curiosities" (i.e. millstone quarries) along their trails (e.g. El Lanchar, J-2; El Berrueco CA-8; Peña Harpada; CA-10, Soneja, CS-1)

Other items on the internet, such as photographs and videos, are also tools to identify these sites. The Medieval quern quarry of Almadén de la Plata (SE-1) would never have come to light without an internet posting of an interview with the local archaeologist, Miguel de Vargas. The internet has also provided amateur historians a platform to publish detailed information about their municipalities. Little would we know about the early 17th-century stone mason Juan de Bargas and the millstone quarry of Albardado (C-10), if it were not for the research by a team of secondary school students from the town of Pozoblanco in Córdoba led by their teacher (González Peralbo 2008, website).

In short, all of these conventional and unconventional sources are preliminary research. The sites identified by these means required confirmation and descriptions that can only be carried out by field work. This was carried out in the case of about a third (48) of the 133 sites.

In many cases, due to the scant information regarding a site's location, and to avoid losing time, we relied on local contacts (amateurs and local historians) to guide us. In other cases, no visit to the site was attempted because it was either too far from our base or because the information of its whereabouts was too vague, requiring days of field work. In sum, it is obvious that if we had been in a position to survey more sites in the field, we would have had a larger data base from which to draw conclusions.

The confirmation in the field of about a third of the sites permitted us to gather field information that was not available from the sources, such as observations about extraction techniques (never described in the sources), volume of the productions, the presence or absence of different phases of production. The physical survey of sites also permitted the collection of rock samples for petrographical and geochemical analyses. On a whole, it must be noted, our visits were unfortunately too short and undertaken without the means of recording precise measurements so as to draft scaled drawings, an aspect that was particularly frustrating due to my past as a field archaeologist, where I was able to record archaeological features in a precise manner.

14.3. Millstone quarry products and their milling installations

Chapter 3 marks a slight "departure" from the principal subject of quarries to briefly describe the different types of millstones and their mechanisms or installations, from small saddle querns to large watermills with their cylindrical millstone-powered waterwheels and complex system of gearing. These descriptions are based, for the most part, on observations made in museum depositories and on descriptions from molinological literature. It is obvious that the understanding of the product, its dating and its evolution goes hand in glove with the understanding of the development over time of quern and millstone quarries. Since the different types of millstones, fittings and means of traction were described in some detail in chapter 3, we will avoid repeating these descriptions and restrict ourselves to placing the different millstone types into the context of their quarries based on the classification undertaken in chapter 6.

As to the introduction of innovative technology, what is noteworthy for our study area is that the date of the transition of the "to-and-fro" motion of the saddle quern to the full rotary motion of rotary quern (and larger millstones) cannot be singled out, probably for lack of research, as it has been in Catalonia (middle of the 5th century BC). It does appear, however, that both small rotary querns and larger man-driven rotary mills were introduced simultaneously in Iron Age contexts. This is a major difference with the introduction of the rotary movement in Central Europe where only small rotary querns are known. It is also logical to assume, although the evidence is scant, that the introduction of water-powered mills took place under Roman domination and that wind power came much later, in the Middle Ages.

The descriptions of the different mill types presented in chapter 3 represent general notions and cannot be considered a formal typological classification. In our opinion, at this stage of the research, the conditions are not present to establish an exhaustive, all-encompassing, typo-chronology of querns and millstones in the south of Spain. Although positive steps are being made for the Roman period, the corpus of stones from all the other periods are poorly represented in the archaeological record. Furthermore, there are still too few well-dated assemblages from which to formulate empirical statistics.

Saddle querns

These earliest models of cereal grinders are typical of settlements from the Neolithic to the middle of the Iron Age. They are common on celebrated late Prehistoric sites like Los Millares in Almería to Early Iron Age sites like Cancho Roano in the Province of Huelva. They were used to grind a number of foodstuffs and other products such as pigments, as seen from traces of *almagra* reddish ochre at Los Pensadores, Granada (Anderson 2010, unpublished).

Most saddle querns, schists, granites and sandstones were probably surface workings (MQ-1a), collected from riverbeds, ravines and taluses, natural features in all likelihood located near the settlements. There is evidence, still poorly documented and hypothetical, of block extraction quarries (MQ-2b). Two of these (Los Pensadores, GR-12; Cabezo de Oliva, MU-2) were "stumbled" upon because they coincide (presumably) with later Roman rotary quern production. The third, EL Barronal (AL-10), in the Cabo de Gata volcanic district, presumably produced querns by prying out blocks from columnar jointing (Carrión 1993; Haro Navarro *et al.* 2006). For more in-depth, specialised studies of quern procurement in these earlier periods in our study area, we refer to the work of Carrión *et al.* (1993), Risch (1995), Haro Navarro *et al.* (2006) and Delgado Raack (2008).

An aspect to retain, related to these "to-and-fro" mills, is the absence in our study area of the Olynthian hopper rubber, in spite of many ports with links to the ancient Mediterranean world. This corroborates that the Olynthian mill was concentrated in the eastern Mediterranean. The closest examples to the south of the Iberian Peninsula are at the shipwreck of El Sec off the coast of Majorca (Arribas 1987), Lattes, in southern France (Py 1992), and Rhodes (today Rosas, Girona) in Catalonia (Genís 1986: 113).

Iron Age rotary mills

Millstone makers in the Iron Age manufactured both hand-querns and larger cylindrical mills. In fact, the two types shared, basically, the same morphology, fittings and rock types. The difference was the means of traction. The smaller "domestic" models, on an average about 35 cm in diameter, were driven, as seen from ethnological studies, at floor level in a seated position. The larger models, about twice the diameter and often discovered *in situ* on podiums, were driven from a standing position. These larger models obviously yielded a larger volume of flour and, in all likelihood, served more than just a family unit. The "inverted keyhole" or "L-shaped" lateral cuttings, an important typo-chronological feature, were present on both models.

In Catalonia and Valencia, these models appear to go as far back as the middle of the 5th century BC (Alonso 1999), and represent at least one of the earliest manifestations of the rotary movement in milling. In the south of Spain, there are no such early models. This is enigmatic, especially considering the high degree of stonework (architecture, statuary) in the Iberian Culture of the south of the Peninsula. Therefore, it is still not certain if the absence of early rotary models is due to the state of research, notably the lack of modern excavations of Early and Middle Iberian Culture settlements, or if the Iberians of the south were reluctant to adopt this new technology.

At the present there is no concrete evidence that these millstone were produced in extractive quarries. Granite and conglomerate examples probably reflect surface working (MQ-1a). This appears to be the case, for example, at the site of Numantia (Soria) where most of the querns are hemispherical and come from outcrops from a short distance (a few kilometres) around the settlement (Checa *et al*. 1999).

In the Sub Bétic range, there is a clear preference toward limestone tufa, a highly porous rock found in fluvial, carbonate-rich contexts. It was exploited around Almedinilla (Córdoba) and furnished millstones to the nearby Iron Age settlement at Cerro de la Cruz (Quesada *et al.* 2010, Quesada *et al*. in press). It is possible that the millstone makers profited from surface blocks detached from large tufa formations (MQ-1a). However, due to the softness of the rock, easily be cut by pick, it cannot be excluded that millstones were hewn directly from bedrock in a true extractive quarry (MQ-2a). Recently, a Roman true extractive limestone tufa exploitation for construction material has been identified near Almedinilla (Muñiz 2012), suggesting that an older similar type of production of millstones might be conserved in the area.

It is noteworthy that no true or direct extraction Iron Age millstone quarries have been identified in Europe. Direct extractive work leaving circular hollows in the bedrock (MQ-2a), from the current evidence, was only introduced in Roman times. This notion was originally suggested by Runnels (1981: 72). Recent work by L. Jaccottey based on findings in France and Switzerland seconds the notion. It would not be surprising, nonetheless, that future work in the south of Spain could bring to light true extractive millstone workings, borrowing from the tradition known throughout the Mediterranean Basin of scoring building stones directly from bedrock.

It is also noteworthy that there is no evidence in our study area of Iron Age volcanic rock workings. This contrasts with the situation in Catalonia, where volcanic rocks, probably from the Olot-Garrotxa district in the Province of Girona, were exploited for rotary querns as early the middle of the 5th century BC (Ca n'Olivé, Alonso 1999: 262, fig. 171).

Roman mills

The Roman conquest is accompanied by a diversification of mills driven by man, animal and (presumably) water. Hand-querns and the larger man-driven cylindrical mills appear to have evolved from indigenous Iron Age tradition, whereas Pompeian mills and watermills, poorly represented in Spain, were mostly imported. Rock types also change with the introduction of volcanic material on a large scale. A great bound was made in the question of production with the introduction of the true extractive method (MQ-2a) of scoring millstones.

Roman hand-querns

The Roman hand-quern, well represented in the museum collections of southern Spain, was made from a variety of rocks, such as biocalcarenites, granites and sandstones, as well as a variety of volcanic materials (dacites, rhyolites, lamproites).

Production took on the form of block extractive (MQ-2b) quarries, such as the Cerro de Limones (Al-1) and Hoya del Paraíso (AL-2) in the SE Spanish volcanic district, where they were pried out from the summits of volcanic columnar jointing (MQ-2b).

They were also produced in the true extractive quarries (MQ-2a), such as the biocalcarenite models that were hewn directly from bedrock at the coastline sites of Trafalgar (CA-1) and Rota (CA- 3). But true extraction was not limited to sedimentary stones. Querns from the lava flows of the volcanic domes outside the Roman city of *Sisaspo* (CR-a) were also cut directly from bedrock leaving the characteristic circular extraction hollows.

The type of production of granite querns is not established. Some querns certainly came from simple surface workings (MQ-1a), profiting from the abundant surface material. It cannot be excluded that more extensive granite outcrops were exploited in the form of either large blocks (MQ-1b) or true extractive quarries (MQ-2a) as were constructive elements.

Roman cylindrical mills

Roman cylindrical mills with their ring-*catilli* and bell-shaped *metae,* best known by the examples at the Roman city of *Volubilis* in northern Morocco, are turning out to be more and more commonplace in the south of Spain. Their role in the history of milling is still not clearly defined. They are often associated with the olive oil industry, as seen through a number of examples that have been brought to light in excavations in or near features related to oil presses (Peña Cervantes 2010: 66).

The recent research of Peña Cervantes (2010), like Frankel before her (1999), associates these mills with the *mola olearia* of Columella, the mill that ground olives into a pulp before being pressed to extract the oil. Peña Cervantes points to the findings of *Volubilis* (Akerraz & Lenoir 2002), as well as to the surveys of Ponsich in the Guadalquivir Valley (1974, 1979, 1987, 1991), and recent archaeological fieldwork, to corroborate this view (Peña Cervantes 2010: 36). Furthermore, the fittings of this type of mill (contrary to the vertical roller) would have offered the option of regulating the space between the stones so as not to crush the olive pit, an action, according to Columella, that reduced the flavour and the quality of the oil (Peña Cervantes 2010: 39, note 50). The ancient author, presumably born and raised in ancient Cádiz, would have been perfectly aware of the different milling mechanisms in the south of Spain.

Yet placing this mill exclusively in the sphere of the oil industry is not doing it justice. Akerraz and Lenoir at *Volubilis* interpreted a dual function of this mill according its rock type. The *grès coquillier* (shell-rich sandstone) models with elongated S-shaped furrows were for crushing olives, whereas the basalt models, devoid of furrows but highly porous, were for grinding grains (Akerraz & Lenoir 2002: 203). J.-P. Brun seconds this "polyvalent" nature of these mills (Brun 1997b: 71-72).

There is still much work to be done on distinguishing the types of millstones destined for the different industries (and other foodstuffs, metals, pigments, paper...). At the present state of research, in our opinion, it is not possible, as was done for the mills of *Volubilis*, to establish the function of cylindrical mills based exclusively from the morphological, typological or petrographical criteria. In spite of the high volume of trade of volcanic stones, not all petrographical types were available everywhere. Furthermore, highly porous volcanic rocks at other sites, reputed to be cereal mills at *Volubilis*, are at times dressed with furrows similar to those reputed for the oil presses at *Volubilis*. This is the case, for example, for one of two volcanic *metae* at Oreto y Zuqueca (Cuidad Real).

From the present evidence, we defend the "multifunctional" aspect of these mills based on the following arguments. 1) Cylindrical mills are, in fact, larger versions of the rotary hand-querns that had traditionally been used for grinding grains since the Iron Age. Their adoption in the oil industry on a large scale only began after the Roman conquest. It is therefore not reasonable that its principal use (for grains) prior to its adoption by the olive oil industry, would have been completely abandoned, particularly in regions rich in cereal production. 2) Due to the scarcity of Pompeian and hydraulic mills, the cylindrincal mill is the only model that could adapt to the "industrial" needs of the bakeries of *villae*, towns and cities. We see with difficulty that this role was played only by hand-querns. 3) The ring-catillus of the cylindrical mill is very similar from the typological point of view to the Roman Haltern-Rheingönheim mill, a model known in Avenches (yellow sandstone) and Basel (*Bundsandstein*) in Switzerland and Saalburg (volcanic rock) in Germany (Castella & Anderson 2004: 129-130; Hurbin 1982; Baatz 1995: 12, fig. 12). This central European mill obviously was not destined to grind olives and those found in Basel were in a bakery (Hurbin 1982). 4) If the cylindrical mills had been dedicated exclusively to the oil industry, they would have remained inactive about half of the year, outside of the span of the olive harvest from Autumn to the end of winter. Contrary to cereal grains, which can be stored for extended periods of time, olives had to be processed in the briefest time possible after their harvest (Pablo Casado and Nanén López, pers. comm.). It is therefore plausible to imagine that some cylindrical mills were at certain times of the year grinding cereals and at other times grinding olives. This would require a thorough cleaning of the mill and adapting the light between the stones to the requirements of each type of milling.

All said, the production of cylindrical mills was widespread throughout our study area. Volcanic models are known to have been made in the Campo de Calatrava at both *Sisapo* (CR-1) and Las Herrerías near Bolaños (CR-2). At *Sisapo*, as seen by circular hollows, they were hewn directly from bedrock (MQ-2a). At Las Herrerías, the extraction technique is not known because the ancient quarry faces have been destroyed by modern extractive work.

Pompeian mills

The situation of Pompeian mills in Roman *Hispania* has been the subject of a recent paper that we presented in the colloquium of Lons-le-Saunier. In fact, these mills are poorly represented in Roman *Hispania*, and for the most part, imported from volcanic production districts elsewhere in the Mediterranean. In the two years since the Lons-le-Saunier colloquium, several new Pompeian *catilli* have surfaced near Empúries (Barcelona), Huesca (Aragón) and two additional examples at Pallaruelo de Monegros (Huesca) (current research conducted in collaboration with L. Jaccottey). All are apparently leucite volcanic rocks from the Vulsini volcanic district near Orvieto, Italy. These finds (and others that will certainly follow in the future) do not alter the hypothesis that most of these mills on Iberian soil are long distance imports. The only certified evidence of a Pompeian model produced on Iberian soil is an unfinished biocalcarenite *catillus*, at *Baelo Claudia* (Cádiz). This example, a local rock copy of a volcanic model, was probably hewn from recycled construction column or block and thus would fall into the category of working large surface material (MQ-1b).

Roman watermills

The subject of Roman watermills in *Hispania* merits a certain amount of ink. It is perfectly reasonable to assume the presence of watermills throughout Roman *Hispania*, especially taking into account the large number of hydraulic works such as the dam of Proserpina near Mérida and the aqueducts that crisscrossed the landscape with its best representations in Segovia and Mérida, fine examples of the rapid transmission of technology from other parts of the Roman world. Closer to the hydraulic grain mill technology were the numerous *norias*, large wooden vertical waterwheels discovered a century ago that elevated water at the Roman mines of Rio Tinto in Huelva (Delgado & Regalado 2012). Nonetheless, there is hardly any trace of watermill installations themselves in the field or in museum depositories of characteristic millstones such as those brought to light in recent years in France and Switzerland.

The only certified Roman watermill in the Iberian Peninsula is at *Conimbriga,* Portugal, where J.-P. Brun recognised the features of a vertical waterwheel (Brun 1997a). Among the 55 millstones in the catalogue of *Conimbriga* by Borges, published two decades before Brun's article, there are only two *metae*, both of siliceous sandstone (Borges 1978: 127, nos. 54-55), that share typological hydraulic millstone features, notably totally perforated eyes, grinding surface angle and slight rim around the edge of the *meta.* A setback to this interpretation is that their diameter (48,4 and 47,3 cm) is smaller than even the smallest Roman models established at 55 cm

(Anderson *et al.* 2004: 6). Furthermore, the absence of volcanic rocks in the collections and no indication of either rynd cuttings or perforations or channels for "*anilles-crampons*" lessens the options of corroborating the watermill identified by J.-P. Brun.

A second potential watermill was pointed out by Philippe Leveau at the Roman villa of El Munts, Altafulla, in Tarragona (J.-P. Brun, pers. comm.). With his experience at the hydraulic works of Barbegal, near Arles in southern France, Leveau is very well-placed to be able to identify this type of installation. Our inquiries among archaeologists with knowledge of the Munts villa, however, have not confirmed this identification.

Elsewhere in publications there are a few reputed Roman watermills. Three are pointed out by García Romero (2002: 623-624, fig. 132-135) in his study of Roman mining in southern Spain. All three, unfortunately, hail from uncertain contexts, and although their diameters are compatible with Roman models, their cylindrical or discoidal form points more to a dating from the Middle Ages. Two other examples appear in a recent article. One is actually a rotary quern *catillus* 34 cm in diameter with radial cuttings (Palomo & Fernández 2007: 517, fig. 8). The nature of the second is less evident. From the photographs (Palomo & Fernández 2007: 514-515, figs. 6-7) and from oral information from Silverio Gutiérrez, director of the Villanueva de Córdoba Museum, we gather that it is about 50 cm in diameter and of conglomerate. Its upper stone is not typical. It has inwardly curved edges and squarish handle cuttings at the four cardinal points, similar to those of cylindrical mills. A fifth dovetail cutting is probably a repair. Its *meta*, not visible in the photograph, has an eye about 3 cm in diameter that is perforated from top to bottom. This is the only feature that is shared with certified hydraulic millstones. S. Gutiérrez nonetheless reports that the mill was discovered *in situ* in a settlement with no indication of a source of water. Hence, at this stage, there is not enough evidence to certify it as a water-powered millstone.

The sole example on Iberian soil that shares the typological traits of the stones of Barbegal (France) and Avenches (Switzerland) is a pierced *metae* measuring 65 cm in diameter (see drawing in chap. 3) decorating the entrance of the archaeological site of Oreto y Zuqueca in Ciudad Real (Anderson *et al*. 2011: 161). Its find-spot, on the outskirts of the ancient centre of *Oretum* and near the Jabalón River, recalls that of the watermills unearthed outside the city of Roman *Aventicum* in Switzerland (Castella 1994). Its volcanic rock points to a local or regional production, from one of the many neighbouring volcanic outcrops in the Campo de Calatrava district. It is not known, however, if the production was of the true or block extractive type.

As we mentioned previously, it is very surprising that no certified watermill installations in the field have been brought to light, especially in the Roman centres of *Corduba* and *Emerita Augusta,* or among the many *villae* excavated in recent years during rescue archaeology. It must be acknowledged that finds of this type in the field, as J.-P. Brun well explains in a recent presentation in Oxford (J.-P. Brun, pers. comm.), are usually extremely poorly conserved and difficult to identify. It may be just a question of time before they begin to appear in the archaeological record of southern Spain.

This absence of characteristic Roman millstones in museum depositories also remains a mystery. We have already evoked the problem they suppose of storage and that they do not leave the excavation. Another possible explanation of their "absence" is that watermill models of *Hispania* were of a different type, unrelated to those identified north of the Pyrenees. In this case the examples presented by García Romero (2002) and Palomo and Fernández (2007) take on a new interest. All said, there is still much research to be undertaken on this subject.

Medieval mills

The Medieval period inherited the wide range of hand-querns, animal-driven, and watermills from the Roman period. The novelty in this chronological period is the introduction of the windmill, sometime during Islamic rule

Rotary hand-querns continued in use. They differed from the earlier models in that they were discoidal with flat grinding surfaces and were driven by means of a vertical handle set in a hole cut into the upper surface, and the rynd cuttings moved from the top of the upper stone to the bottom. The few quarries identified such as the Arroyo de las Calzadillas (SE-1a) in Seville, Zagra (GR-5) in Granada, Rambla Honda (AL-3) in Almería and Puerto de la Cadena (MU-1) in Murcia are true extractive productions (MQ-2a). The first two sites (GR-5 and SE-1a) produced standardised querns measuring about 50 cm in diameter. Querns of this size are typical in museum depositories throughout our study area. The other sites (AL-3, MU-1), among the many extractions of larger size, produced slightly smaller models around 40 cm in diameter.

A different impression is obtained from the largest published Medieval quern assemblage at El Castillejo, Montefrío (Granada), dating from the 9th to the 12th century (Motos Guirao 1987), is that of a variety of non-standardised models measuring between 20 cm to 50 cm in diameter reflecting surface workings (MQ-1a) instead of true extractive quarries (MQ-2a). We can therefore envisage, at this stage, the coexistence of both surface workings (MQ-1a) and true extractive bedrock extractions (MQ-2) for querns of the Middle Ages, as was the case in Roman times. However, we do not know if the proportion of surface workings (MQ-1a) was feeble as in Roman times, or if it represented a large proportion of the production.

At several of these quarries, querns are found side by side with larger extractions for animal or water-driven mills. The animal-driven *tahonas* were the natural heir to Roman "donkey" mill tradition and were installed in areas where access to running water was difficult. The major differnce at this time, compared to Roman times, is that there is no evidence of man-driven mills. Cordóba de la Llave (1988: 839-840) reports their existence in the Province of Córdoba. However he notes that none was known in the City of Córdoba. These mills most likely took on a minor role to that of watermills and no specific quarry production can be attributed to them. However, it is likely that part of the production of true extractive quarries such as that of Rambla Honda (AL-3) and Puerto de la Cadena (MU-1), both in very dry regions, might have been destined to these mills. Yet, we ignore if these stones are equivalent or different in diameter to those of watermills.

Our knowledge of watermills in Medieval times in our study area is founded on a large amount of molinological research, notably that of Cordoba de la Llave (1988, 2003, 2011) in Córdoba, Reyes Mesa (2000, 2006) in Granada and Cara Barrionuevo (1999) in the Alpujarra Mountains of Almería. A very early reference is in a recent article citing an old Islamic narrative (Ajbar Maymu'a) reporting that the ruler Abul-Jattar, during internal conflicts in 743, took refuge in the Kulayb watermill along the Guadalquivir River (Palomo & Fernández 2007: 499). Little is known of the millstones that equipped these early watermills and where they were procured. They are neither found in museum depositories or illustrated in archaeological publications. This absence can probably be explained (following the model proposed by J.-P. Brun for Roman hydraulic mills) by way of the few excavations of settlements from the Middle Ages have focused on the urban sectors and not on the settlement periphery, where the watermills are probably located.

From research undertaken elsewhere, notably in Switzerland, the tendency is for these larger millstones to become cylindrical with flat grinding surfaces (Castella & Anderson 2004: 134-135). As to fittings, the eyes of both upper and lower stone are pierced and rynd cuttings are restricted to the base of upper stone.

The very low quantity of characteristic typological features on Medieval millstones does not provide elements for dating. Their diameters also fall into the range of those corresponding to more recent Modern and Contemporary millstones. This, therefore, annuls any attempt at dating based on the indicator of diameter surpassing 1,00 m.

With the growing number of mills in Medieval times, especially water-powered mills, there was also a growing demand of millstones for new mills and to replace those that have worn out. Due to this growing demand, and the large size of the millstones, it is hard to imagine millstone workings that did not exploit bedrock (MQ-2) either in the form of true extractive (MQ-2a), block extractive (MQ-2b) or large loose boulder quarries (MQ-1b). But since these millstones share similar sizes with those of later Modern and Contemporary millstone workings, it is very difficult to identify them in the field based simply on the morphometrics of an extraction hollow.

Larger millstone extractions that shared the same space with smaller quern extractions at sites such as the Rambla Honda (AL-3) and Puerto de la Cadena (MU-1) can probably be dated to the Islamic domination. The absence of Latin-based place names and the abandonment of volcanic rocks in favour of conglomerates, also supports a Medieval dating for these sites. It is also highly likely that more recent workings at quarries from Modern and Contemporary times, such as Moclín (GR-1a) and El Berrueco (CA-8), destroyed or hide earlier Medieval extraction phases.

Most windmills in Spain are found in areas that had a poor water supply. In the southern half of Spain there are two main concentrations. The first is in Don Quixote's La Mancha where many with their rectangular vanes of wooden slats can be seen today. The second concentration is in the southeast, in one of the driest regions in Spain. The vanes of these windmills are triangular sails (Rojas & Amezcua-Ogáyar 2005). In any case, there is no evidence that extraction techniques of millstones destined to windmills were any different from that of their contemporary watermills. These mills were therefore supplied essentially by bedrock quarries (MQ-2).

Modern and Contemporary mills

Modern and Contemporary mills, although undergoing some technical changes that are beyond the scope of this work, are practically identical, from the standpoint of their stones, to those of the Late Middle Ages. These most recent periods are the heyday of millstone quarries and correspond to the time when mills were ubiquitous throughout the landscape. As noted in a previous chapter, at the time the Madoz geographical dictionary was published (1845-1850), throughout the landscape of the Iberian Peninsula there were 22,492 flour watermills, 676 windmills and 1476 *tahonas* (animal-driven flour mills) (Lizarralde 2010). It is obvious from the number of watermills, in particular the *rodeznos* with horizontal waterwheels, were by far the most dominant type, outnumbering by far the windmill and the *tahona* installations. These numbers are seconded by the work of Reyes Mesa that registers only two windmills in a total of 542 in the Province of Granada (Reyes Mesa 2006: 213). This is, of course, a radical difference from the impression of Spain offered by the tale of Don Quixote. Rotary hand-querns in these times are relegated to a grind animal fodder. They are included in this study because they were known to also have served to grind foodstuff for human consumption, especially during difficult times, such as during and after the Spanish Civil War.

In these later periods, bedrock quarries (MQ-2) account for most of the millstone quarry sites identified in our study area. The technique of direct or true extraction resulting in circular hollows (MQ-2a) or block detachment (MQ-2b), depended on the nature of the rock outcrop. In some of the larger exploitations such as Moclín (GR-1a) and Cabra, Cantera de los Frailes (CO-1), the millstone makers carved directly into the rock (MQ-2a) leaving numerous tubular shaped quarry faces covered with diagonal pick marks. In other cases, such as Alhama de Granada (GR-6) and Carcabuey, Cudillas (CO- 3), millstones were hewn from angular blocks detached by levers (MQ-2b).

In addition to the large productions, there were other more discreet quarries with a very limited number of extractions. This is the case, for example of the extractions of large surface blocks that served as quarries at Arbunuel (J-4) in Jaén and at Molino de la Piedra (CO-5) near Baena. The direct extractions from large surface blocks (MQ-1b) at these two sites were probably destined to neighbouring watermills.

Finally, the sources of the rotary querns for grinding fodder have not been identified, leading us to think that they came from quarries where the angular blocks were detached (MQ-2b) leaving no extractive traces in the field.

14.4. Millstone quarry geology

Millstone makers sought out hard and abrasive rocks that were either porous or contained inclusions or crystals to increase the "bite" of the stones. We have established that millstone makers through time exploited nine main rock types in the south of Spain. Some of them were worked in specific time frames, while others were exploited over long stretches of time.

Most of the identification is macroscopic. The only geochemical analyses we have undertaken were done by the laboratory of the Norwegian Geological Survey (NGU) in Trondheim, Norway. These analyses were undertaken on volcanic samples from the Cabo de Gata in the SE Spanish Volcanic District and from the Calatrava Volcanic District and are published in a recent article concerning Roman volcanic quarries (Anderson *et al.* 2011: 157). A dozen other analyses are currently being undertaken by Jane H. Scarrow and Aitor Cambeses of the Geological Department of the University of Granada, from samples of volcanic millstones from the Museum of Murcia. Preliminary results confirm the exploitation of local or regional lamproites. These analyses, alluded to on several occasions in this work, are yet to be completed.

The following is a list of the major types identified in our study area:

Sedimentary rocks

In general, a number of sedimentary stones were exploited throughout the whole of southern Spain for millstones. Some rock types were more sought after than others. They can be separated broadly into coarse and fine rocks.

Among the coarse rocks are the yellowish, porous, shell-rich "*ostionera*" biocalcarenites, exploited since Prehistory (for saddle querns) until the 20th century for querns and millstones in quarries along the Bay of Cádiz on the Atlantic coast. Since Roman times, this stone was also highly prized for construction material.

Brownish pebble conglomerates, or puddingstones, were exploited on a large scale for millstones. Most of these outcrops were found in the Bétic Range, south of the Guadalquivir River Basin. The size of the pebbles could vary in size from 2 cm to up to 10 cm. This rock does not appear to have been valued in Romans times. Its exploitation became common in the Middle Ages and lasted until Contemporary times.

Highly porous, cream-coloured limestone tufas, at times called "travertines", were sought for querns and millstones in the Iron Age and, to a lesser extent, in Roman times. In the Province of Guadalajara, to the north, there is a concentration of these exploitations dating to Contemporary times. In fact, the name of the hamlet of Tobes (GUA-5), a known producer of millstones, derives from the name of the rock (*toba*).

Among the finer sedimentary stones sought out for millstones are the bright white limestones, white (sometimes greyish) dolomites and pink *rosso ammonitico*. These outcrops, located for the most part to the south of the Guadalquivir River Basin, were ostensibly exploited from the end of the Middle Ages to the 19th century. The more renowned exploitations are El Berrrueco (CA-8), Moclín (GR-1), El Torcal (MA-1) and Cabra (CO-1). These stones required constant dressing and probably were appreciated because they yielded white flour.

Metamorphic rocks

The only metamorphic rock identified in our study is schist. Mica schists with garnet crystals that projected from the grinding surfaces and enhanced the "grinding bite" of the quern, were highly appreciated for saddle querns in Prehistoric and Protohistoric contexts. These were most likely gathered in simple surface workings. The only recent schist quarry exploiting large cylindrical millstones that we have identified is at El Campillo in the Province of Huelva (HU-1). The little use of schists in our area of study contrasts with the massive exploitation of this rock in Norway at the Middle Age garnet schist quarries of Hyllestad, and the Modern staurolite schist quarries at Selbu (Grenne *et al.* 2008).

Igneous rocks

The first igneous rock group comprises a variety of very hard, granular, crystalline rocks that fall globally under the term granitoids. In Spanish, these outcrops are commonly called "*rocas berroqueñas*". Variations of the term "*berruequeño*" are found as toponyms. Granitoid outcrops, in our study area, are circumscribed in a vast area to the north of the Guadalquiver River Basin from the Province of Extremadura to Jaén, and are present in the form of extensive surface outcrops. In certain areas, natural agents have sculpted the outcrops into rounded surface boulders. These rocks, easy to detach from the bedrock, lend themselves to millstone workings. Granitoids were exploited continuously since Prehistory for saddle querns to the 19th (or 20th) century for large watermill millstones.

The second igneous rock group comprises a range of black, grey, or reddish-purple vesicular volcanic rocks. In the south of the Iberian Peninsula, they hailed from specific outcrops in the two volcanic districts: 1) Southeastern Spanish Volcanic District, spread through the provinces of Almería, Murcia and part of Albacete and 2) the Campo de Calatrava district in the Province of Ciudad Real in the centre of our study area. Although they can be identified by the trained eye, establishing a precise portrait of these rocks (rhyolites, dacites, basalts, lamproites, melelinites) requires petrographical and geochemical analyses. There is evidence that these rocks were exploited since the end of Prehistory. However, it was in Roman times that they saw their greatest use for rotary querns and man- or animal-driven mills and are known to have been traded, at times, very long distances.

To conclude this chapter, it is noteworthy that no exploitation of porous, hard siliceous, rock similar to that known as the French Burr (exploited on a vast scale for example at La Ferté-sous-Jouarre) has been identified in the Iberian Peninsula. The closest Iberian rival to the French Burr was the hard sandstone quarry of Montjuïc of Barcelona, a millstone exploitation that exported its millstones up and down the Mediterranean coast and beyond.

14.5. Millstone terminology, topography, techniques

The terminology we have employed to describe extractive techniques of millstone quarries is borrowed, in part, from that of construction quarries. The research of J.-C. Bessac (1996; 2003), on ancient quarry tools, "*gestes*" and extraction sites, is pervasive throughout this study. Some definitions such as "*direct percussion*" and *"indirect" percussion*, are rough (and awkward) translations of the techniques Bessac has defined as "*percussion posée*" or "*percussion lancée*".

For more specific millstone quarry terminology, we have borrowed from Crawford (1955), Runnels (1981), Tucker (1985), Peacock (1986; 1987) and Jobey (1986). The English terminology is also strongly influenced by the French publications of A. Belmont (2006; 2011a; 2011b) and that of the *Groupe Meule* (Buchsenschutz *et al*. 2011). For example, the term "tube" or "tubular", ubiquitous throughout this work in reference to multiple, superimposed, circular extraction hollows, is a direct translation from the French cognate. For the Spanish terms we have relied on personal communications and publications of Pilar Pascual and Pedro García (Pascual & García 2011) based on their work in La Rioja (and surroundings) and Joaquín Sánchez in Minorca (Sánchez 2011). The recent research of Maestro Hernández (2011) relative to millstone workings in the mountains of Palencia, has also provided useful Spanish vocabulary. Due to the growing international interest in querns, millstones and millstone production, a multilingual glossary, developed already in part by F. Jodry of the *Groupe Meule* (Jodry 2011), is a vital project for the future.

The topography of millstone quarries

In this sector, we have defined the topographic features where millstone quarries most often occur. These are the following: a) slope quarry; b) cliff or scarp quarry; c) ravine bottom or riverbed quarry; d) valley or ravine edge quarry; e) plateau quarry; f) coastline quarry. These all coincide in that they are features where either the bedrock is exposed at the surface (or very near the surface), or where suitable surface blocks have accumulated, for the most part by natural processes. Quarry classification and morphology, developed in chapter 6, are dependant, in part, on this aspect. We have, nonetheless, retained the subject of topography in this chapter so as not to multiply the variables that went into establishing a classification of quarries (see chapter 6).

Production tools and techniques (extraction and fashioning)

As to the description of the millstone maker's tools, we have limited ourselves to their interpretation from the marks visible at the quarries we have visited, and to the information illustrated in the photographs of millstone workers in the mountains of Palencia and at the Montjuïc of Barcelona (notably the pick and the lever). It must be remembered that the tool marks at the quarries we have surveyed, as we see them today, are usually too poorly conserved to permit a fine analysis. Serious tool mark study can only be undertaken in the framework of modern archaeological excavations where well-conserved examples protected under soil and rock debris, can be uncovered and analysed. Hence, the extractive techniques presented in this chapter are based principally on the work of Bessac (1996), and highly influenced by personal observations from the excavations of Châbles in Switzerland (Anderson *et al*. 2003), as well as from the digs of millstone quarries in France at Claix (Charente) and Mont Vouan (Haute Savoie) under the direction of A. Belmont.

Parting from the point of view that "a picture is worth a thousand words", we have attempted to reconstruct the different extraction techniques by means of drawings. Each technique depended greatly on whether the bedrock was naturally compact and homogeneous or included natural fissures that served for block extraction. In general, a pick was used to trench or channel through massive, homogeneous bedrock, whereas a lever or crowbar was used to pry out blocks from bedrock with natural fissures.

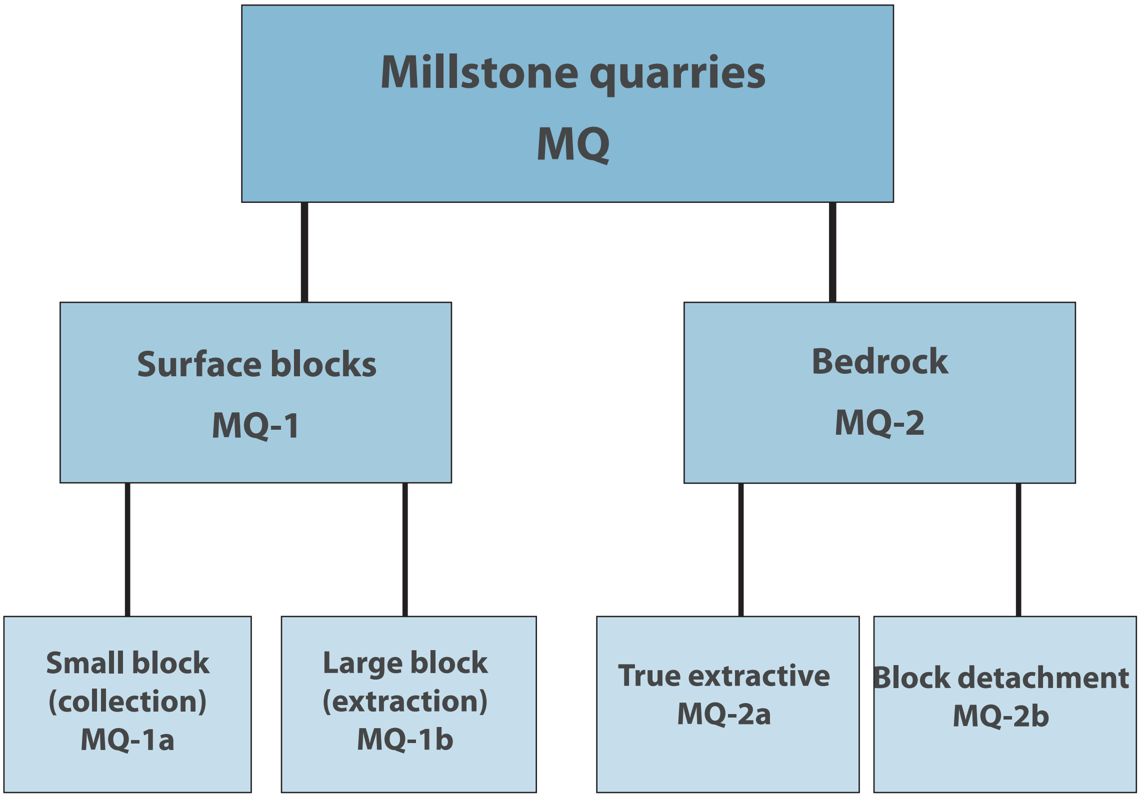
Fashioning techniques, the phase of work subsequent to the extraction, varied depending on the type of product and the rock type. In this chapter, we explore the "*chaîne opératoire*" of quern and millstone fashioning that varied depending on whether the source was 1) a simple surface block, 2) an angular roughout detached from a block quarry, or 3) a rough cylinder scored from bedrock in a true extractive quarry.

In this chapter, we also briefly describe production of composite millstones, that is, non-monolithic millstones assembled with plaster from different stone segments and bound with iron bands. The quarries of these millstones, certified through a number of historical sources, like other block quarries, are difficult to identify in the field. This is because they do not leave the characteristic circular hollows and because their assemblage took place elsewhere, probably at a smithy.

From experimental work undertaken in Switzerland (Anderson *et al*. 2003: 47), we propose that, on an average, a rotary quern (including both stones), from extraction to fashioning, took between two to three days to make. By contrast, a larger single millstone took longer, between three to seven days, as indicated by Maestro Hernández when describing early 20th century work in Palencia (2011). From information provided by Madoz concerning the amount of yearly production at El Berrueco (CA-8) (Madoz 1846, Vol. 4: 290), we arrive at a number of two a week by a team of four to five workers. Of course, these estimations vary depending on the hardness of the rock and the skill of the millstone makers.

14.6. Millstone quarry classification

The route leading to the system of classification of millstone quarries (MQ) in chapter 6, considering its simplicity, has been extremely circuitous. For the classification of the sites in the south of Spain, we first attempted to include all of the variables, that is, topography, extractive techniques and the morphology of the sites, as well as observations of other sites in France, Switzerland and Germany, After a series of tests, we came to the conclusion that a classification including all of these variables resulted in an incongruous system with almost as many categories as the number of quarries.



Organisational chart of the classification of millstone quarries identified in southern Spain.

We have therefore opted for an extremely simple classification rooted on the nature of the rock. Hence, millstone quarries exploiting loose surface blocks are labelled with the number 1 (MQ-1), and those exploiting bedrock are labelled with the number 2 (MQ-2). Each of these general classes are then subdivided into two parts as explained below.

Small surface block collection (MQ-1a)

Small surface block quarries are sites associated with specific topographical features such as riverbeds, ravines, taluses, screes and moraines comprising accumulations of rocks with proper milling properties that could be *repeatedly* collected without difficulty as loose surface material without the need of digging them out of the ground. These boulders were usually sculpted by natural processes into a shape close to that of a quern. The word "*repeatedly*" is stressed since isolated, random collection of surface material does not constitute a quarry. Although these sites were without a doubt numerous, they are almost impossible to identify in the field because they have left practically no perceptible evidence.

Although not identified in the field, these workings can be inferred from the general shape and observation of the surface patina of saddle and rotary querns. Saddle querns with rounded bases and hemispherical rotary querns, due to their rounded shape, suggest they were fashioned from rolled boulders. This is confirmed when a difference of surface texture can be observed between the original unworked, rolled surfaces (the original cortex) resulting from natural processes and unnatural knapped and pecked surfaces (Anderson & Castella 2007: 153).

From the large quantity of saddle querns from late Prehistory, the Bronze Age and the first half of the Iron Age in museum collections, it is reasonable to assume that these quarries were ubiquitous throughout the landscape of southern Spain. For the most part they were near settlements, so as to reduce the time and effort of transport.

Their petrography is varied and depended on the geological surroundings of the settlement. In the eastern half of our study area, mica schists, sandstones and conglomerates are dominant (Delgado Raack 2008: 138). In the volcanic districts in the Province of Almería, dacites and rhyolites would have been available as surface material. In the western areas, granites were also probably the dominant surface rock, as seen through the saddle querns of the Early Iron Age site of Cancho Roano (Huelva).

For the more recent phases of the Iron Age and the Roman period, no site of this type has been documented in our study area. Although extractive quarries began progressively to dominate millstone production, especially in Roman times, surface material continued to be exploited as a local alternative to importing exogenous products. In La Rioja near a Roman Villa, there is evidence of surface boulder workings for querns from nearby alluvial deposits (Pascual & García 2010: 287-288). In Roman Switzerland, granites, schists, gneisses and *verrucanos* were exploited as surface boulders and served as local alternatives to querns hewn in quarries of reddish breccia, *grès coquillier,* and *Bundsandstein* quarries (Anderson *et al.* 2003: 64-67). In Norway, in these early times, erratic block production seems to have been the norm and outnumbered that of extractive quarries (Dahlin & Anderson, in press). The ubiquity of gneiss, granite and schist erratic blocks, may have even held back the emergence of the mica schist extractive quern quarries at Hyllestad until the 8th century (Grenne *et al.* 2008: 48, 64).

All said, exploitations of surface blocks, although now invisible to the eye of the archaeologist, were the quarry type *par excellence* of Prehistory and Early Protohistory. Although they continued to exist in later periods, their production was proportionally low compared to that of extractive quarries. At the technical level, these workings only required the knowledge of stone fashioning, by means of knapping and pecking, and, in the case of certain rotary querns, splitting the boulder into two equal parts. Most importantly, these exploitations did not require the skills and tools of the bedrock extractive productions.

Extracting from large surface blocks (MQ-1b)

The second type of quarry is a variation of the surface block quarries. It is differentiated from small boulder collection (MQ-1a) in that the surface blocks exploited were much larger and impossible to collect or transport. Hence, in this sense, they served as extractive quarries and required the skills and tools of extractive workings.

They have been divided into four groups (MQ-1b-1-4). The first two (MQ-1b-1-2) are similar and correspond to large blocks displaced by natural processes. MQ-1b-1 corresponds to taluses comprising multiple large blocks from which a number of millstones can be extracted. Examples are the sites of La Perdrizas near Moclín, Granada (GR-1b), Castillo de Locubín, Jaén (J-1) and Vélez de Benaudalla, Granada (GR-10).

In the case of the second, MQ-1b-2, the source consists of only one single large block resulting from landslides, such is the case at Arbuniel, Jaén (J-4) and Molino de la Piedra, Córdoba (CO-5). This second type could also include large erratic blocks, a type that is known elsewhere but has not been determined in our study area. Although the extraction techniques are identical, the number of extractions from one type of site to another is very different. Talus productions (MQ-1b-1) are potentially much larger than single block productions (MQ-1b-2).

The third type, MQ-1b-3, is that of large natural surface slab and pedestal boulder workings found in certain geological units. The difference with the previous type is that they were not transported by landslides, torrents or glaciers but engendered, *in situ*, after millions of years by means of agents of erosion. The best examples are the karstic loose block formations at the sites of El Torcal (MA-1), Teba (MA-2) and Fuensanta, Loja (GR-2). Another example of this type of exploitation is that of loose surface granite *bolos* or *piedras caballeras* (pedestal rocks), rounded surface boulders also formed *in situ* by agents of erosion in granite units.

The fourth (MQ-1b-4) is that of blocks originally destined to architecture that were recycled into millstones. A specific example is the Pompeian upper stone at the Roman city of *Baelo Claudia* scored from a bio-calcarenite ashlar or column drum. Another example is the presumed use of drum segments of the Roman column quarry of Cerro Bellido (SE-4) as millstones in the Middle Ages.

It is difficult to quantify these productions. The cases of MQ-1b-1 are usually alternative productions related to a nearby extractive quarries, as is the case of large talus blocks of Moclín (GR-1b), less than a kilometre from the vast extractive quarry with the same name (GR-1a). Some examples of MQ-1b-2 appear to be very local productions near or beside watermills, and may have been a provisional means to rapidly replace a broken millstone while waiting for a permanent replacement. These extractions may also have been destined to more menial chores such as grinding fodder. The MQ-1b-3 type, due to the unlimited quantity of surface material, could potentially be vast productions, attaining a wide sphere of distribution. This is presumably the case of the sites of El Torcal, Málaga (MA-1) and Loja, Granada (GR-2/3). MQ-1b-4, recycling blocks from architectural features, is almost "anecdotal" and poorly represented in our study area.

Bedrock exploitations (MQ-2)

The second large division of millstone quarries is that of sites that exploit massive bedrock (MQ-2). These sites differ from loose block exploitations because they require an extractive process that entails a high degree of skill, as well as a panoply of tools that require constant maintenance and repair. In these cases we can speak of veritable "professional " mill makers, or *moleros* as they are called in Spanish. These sites represent the most economic manner to exploit rock and allowed massif outcrops to be exploited intensively and over an extended period of time. They are subdivided into two large classes according to the type of extractive process. At true extractive or direct extractive quarries (MQ-2a) the workers channelled directly into the rock mass resulting in quarry faces with characteristic circular hollows and tubes. At block detachment quarries (MQ-2b), by contrast, workers detached angular-shaped block by means of levers. Their uncharacteristic quarry faces are much more challenging to identify in the field.

True extractive millstone quarries (MQ-2a)

True extractive millstone quarries, a term borrowed from Runnels (1981: 72), are sites where querns and millstones were scored by cutting them directly from massive and homogenous bedrock leaving the characteristic circular extraction hollows. These productions require a skilful use of the pick, the tool that by means of the technique of direct percussion cuts the circular trench or channel. The typical site of this type, when conservation is ideal, presents tubular shaped quarry faces resulting from multiple, superimposed, horizontal extractions, with faces covered by diagonal pick marks. The quarry floors, when conserved, bear the marks of cylinder splitting, whether these be wedge holes, wedge channels, chisel or pick marks.

Detached block millstone quarries (MQ-2b)

Block detachment quarries differ from true extractive quarries in that blocks are not cut directly into the bedrock but are detached, profiting from natural fissures. Therefore the roughout extracted is not cylindrical but angular. The main tool of extraction at these sites is not the pick but the lever or crowbar that pries out the blocks. In this case the bedrock is not massive and homogeneous, but characterised by natural fractures. The quarry faces of these quarries do not readily reveal that anthropic extractions have taken place. These extractions can, in fact, be mistaken for natural mechanical processes such as gelifraction. Since they are difficult to identify in the field, it is usually the presence of unfinished or broken cylinders at the site that betray their existence.

The morphology of extractive millstone quarries

The definitions of the morphology of extractive millstone quarries are based on terms borrowed from the vocabulary of construction quarries. Several terms such as bench, pit, trench, edge and pocket are common types of open air workings. The term "pocket" quarry in our study is associated with multiple small exploitations on slopes. Subterranean quarries, although common in southern Spain for construction material, are only represented in our study area by one site. The two remaining types, extensive contiguous shallow quarries and extensive dispersed quarries, inspired from the work of J.-C. Bessac (2003), are less common in the realm of construction but lend themselves well to certain millstone exploitations. These terms are all related to the features of the outcrop including its size, accessibility, inclination and depth, direction of work progression, and whether the extractions were contiguous or dispersed.

The question of subterranean millstone quarries deserves a few extra words. The identification of only one subterranean millstone quarry in such a vast study area is surprising, especially considering the long tradition of underground mining, starting with flint shafts from the Neolithic at Vicálvaro in the outskirts of Madrid (Consuegra *et al*. 2004) to the Roman underground galleries of silver and gold in Murcia and Almería. There are also a number of Roman underground construction quarries at Peñatejada outside Córdoba (Penco Valenzuela *et al*. 2004: 235-238) that supplied the Roman city of *Corduba*, as well as underground exploitations from the Middle Ages at Puerto de Santa María, Cádiz, that provided the blocks for Cathedral of Seville (Jiménez Martín 2006: 179).

Elsewhere in Europe, volcanic millstones were extracted in underground galleries at Mayen, Eifel (Germany) (Hörter 1994; Harms & Mangartz 2002), and most recently at the Mont Vouan in Haute Savoie, France (archaeological excavations directed by A. Belmont). Nearer to our study area, in Morocco, on the opposite side of the Straits of Gibraltar, is the celebrated "*Grotte d'Hercules*" (Tangiers) visited by Curwen in the 1950s. This pioneer of millstone studies actually witnessed quern makers at work in the cave by candlelight (Peacock & Williams 2011: vii).

In our study area, the sole underground millstone quarry is at La Merced, Loja (GR-4b). We cannot propose an explanation for the absence of other subterranean sites. Future research on this question will certainly unveil more of these sites that are now, presumably, caved in and hidden from view. In any case, La Merced (GR-4b) is a very small site, only a few meters deep. Hence the millstone makers did not have to cope with the problems linked to deep underground galleries, that is, illumination, ventilation, rise of the water table and hoisting the products out of the cave.

Comments on the chronology of millstone quarry types

In general, millstone quarry types follow a chronological pattern. Simple surface workings (MQ-1a) exploiting loose surface boulders is the oldest type of millstone exploitation, covering the periods from Prehistory and Protohistory. There is also evidence of surface workings in both Roman and Medieval times as seen through hand-querns, at times poorly-made, especially of rock types that are not commonly exploited in quarries. But these Roman and Medieval workings were a minority, far behind the massive production coming from both true extractive (MQ-2a) and block detachment quarries (MQ-2b).

Block detachment quarries (MQ-2b) are also known since early times. The sites of Zujaira (GR-12) (Anderson 2010, unpublished) and El Barronal (AL-10) (Haro Navarro *et al*. 2006) presumably supplied detached blocks for saddle querns by prying out slabs from bedrock. Once again, however, these workings were probably the exception and took on a secondary role far behind that of simple surface workings (MQ-1a). It is in the Late Iron Age, with the production of rotary querns, that block detachment quarries reach a new, unprecedented state. Although none has been identified in our study area, pre-Roman rotary quern block productions centres are known throughout Europe, notably at Lodsworth in England (Peacock 1987), in the Lovosiche district in the Czech Republic (Frölich & Waldhauser 1989), at Fossotes, La Salle in the French Vosges (Farget & Fronteau 2011) and at Schweigmatt in Germany (Joos 1975).

True extractive quarries (MQ-2a), as Runnels suggested three decades back in his work on Greek millstones of the Argolid (Runnels 1981: 74), are an innovation dating to Roman times. This idea is seconded recently by L. Jaccottey (pers. comm.) based on the surge of millstone quarry research in the last years. This is evidenced, for example, by several examples of true extractive Roman rotary quern quarries, notably the Serre quarry in the French Jura (Jaccottey 2011: 300) and three sites in Switzerland (Châbles FR; Chavannes-le-Chêne VD; and Würenlos AG) (Anderson 2006).

An excellent example of the change from the Iron Age block extraction technique to the Roman true extractive technique is found in the Upper Rhine Valley. The Iron Age technique is exemplified by the Schweigmatt quarry exploiting reddish breccia blocks in the German Black Forest. From all the evidence, the Schweigmatt querns were subsequently supplanted by Roman querns hewn from the reddish sandstone (*Bundsandstein)* true extractive quarries (Anderson *et al*. 2003: 64, 66). There are certainly several reasons for this change. The location of the Schweigmatt site, in the hills of the Black Forest, was less accessible and less extensive than the *Bundsandstein* quarries, probably found along the shores of the Rhine River. Finally, and what concerns us here, is that the true extractive *Bundsandstein* workings probably eclipsed those of the Schweigmatt because they produced a higher yield of standardised products (Anderson *et al.* 2003: 64, 66).

In our study area, examples dating to the Roman times of true extractive work are evidenced at the volcanic workings of *Sisapo* (CR-1) in Ciudad Real and at the biocalcarenite exploitations along the Bay of Cádiz, such as Trafalgar (CA-1) and Rota (CA-3). Therefore, at this stage of the research in the south of the Iberian peninsula, all the evidence reinforces the model that true extractive quarries (MQ-2a) only appeared after the Roman conquest. But it would not be surprising that future research in our study area, due to the long tradition of stone work for statuary and architecture of the Iberian Culture, might identify pre-Roman true extractive quarries.

14.7. Millstone quarry toponymy

Although place name study in the framework of millstone quarry research is essential, the results in southern Spain have not been as conclusive as those in France and in the north of Spain. The toponyms *Molière* and *Moulière* from the Latin "*mola*" (meaning mill) have resulted in the identification of many millstone quarries in the French Dauphiné, some dating as far back as the 13th and 14th centuries (Belmont 2006, Vol. 1: 56-59). Likewise, the work of P. Pascual and P. García in the north of Spain, tracing the name *Molares* (millstone quarry) and its derivatives, has also resulted in the identification of a number of quarries (Pascual & Ruiz 2011: 285-286).

The searches based on the name *Molares* in our study area, by contrast, have identified only few sites: Almonaster la Real, Huelva (HU-8), Molares, Cuenca (CU-1) and Tobes, Guadalajara (GUA-05). There are derivatives of *Molares*, also presumably linked to millstone working such as the *Piedras Moleras* (CO-11) by Villanueva de Córdoba. There are also a half dozen sites linked to *Moles*, *Mola, Molar* or *Muelas* that might have nothing to do with millstone workings but a natural topographical feature, notably a butte or flat topped hill (Sans Elorza 2012).

By contrast, there are relatively many sites linked to the name *Cantera*, simply meaning quarry: *Las Canteras*, Colmenar de Oreja (M-2), *Las Canteras*, Granátula de Calatrava (CR-5), *Cantera Honda*, Paterna (CO-8), *Las Canteras*, Moclín (GR-1a), *Rambla de las Canteras*, Caniles (GR-11), *Las Canteras*, Ugíjar (GR-14), *Cantera de las Pilas* (CA-9), *Las Canteras*, Castillo de Locubín (J-1), *Cantera de los Frailes*, Cabra (CO-1), *Cerro de la Cantera*, Huelma (J-3), *Las Canteras*, Guadalquitón (CA-13) and *Las Canteras*, Alhaurín el Grande (MA-3). It is interesting that most of these "*cantera*" sites show no signs, contrary to what their name suggests, of extractions for anything else but millstones.

The small proportion of *Molares* names, as opposed to *Canteras* is intriguing. We wonder if this change of name was introduced during the influx of construction stone masons (*canteros*) after the fall of Islamic rule from other areas of the Peninsula to work on the numerous secular and religious architectural projects, as well as millstone quarries, initiated after the Reconquest.

14.8. Millstone quarry infrastructure

Research in southern Spain regarding millstone quarry infrastructure is practically nonexistent. As we have stated on several occasions, no site has benefited from an archaeological excavation that might shed light on the structures and facilities linked to the operation of millstone quarries. This obliges us to rely on field observations and on a few references from old texts. We also depend heavily on the research undertaken in the north of Spain, as well as the results of excavations of the few sites elsewhere in Europe.

Tool repair and maintenance

The picks, chisels and wedges of millstone makers, the tools that were used to carve and split the rock, had to undergo constant maintenance. Some tools simply suffered from wear at a rate that depended on the type of stone they were carving. Others broke during use. Their repair and maintenance required the skills and infrastructure of a blacksmith.

Small millstone productions did not have direct access to a smithy. The workers had to plan in advance the number of tools to take to the site so as not to interrupt their work as a result of an unwanted break. These productions had to rely on the local blacksmith or possess the skills and tools to undertake these tasks themselves, as was the case in the Palencia mountains of some millstone makers who doubled as blacksmiths (Maestro Hernández 2011: 38, 43). At Châbles in Switzerland, the small Roman hand-quern workings had access to a smithy a stone's throw away (Anderson *et al.* 2003: 59), as did the millstones workings at Gardom's Edge, Baslow, Derbyshire in England (Radley 1964) and Vioménil in France (Vosges) dating to the 17th-century (see Atlas of European Millstone quarries http://meuliere.ish-lyon.cnrs.fr/php/results2.php).

There is also evidence that certain millstone quarries possessed their own smithies. This was the case of Medieval workings at the Mont Vouan in Haute Savoie where the workings appear to have been so great and intensive so as to merit having a smithy dedicated exclusively to the quarry placed in the back of a cave of the Grand'Gueule (Belmont & Anderson 2010: 104-108).

In southern Spain we have not observed any evidence of smithies at any millstone quarry. This type of work does not necessarily leave behind evidence that can be readily observed. It must be noted, nonetheless, that all the smithies identified at millstone quarries elsewhere in Europe have been discovered in the context of archaeological excavations. It is therefore not surprising that none has been pinpointed in our study area.

We can speculate that the large production at Moclín (GR-1) would not have needed an independent smithy because the workers could have accessed a smithy in town, just a short walk away. By contrast, it is difficult to imagine that the vast production at El Berrueco (CA-8), 10 km from the nearest town (Medina Sidonia) and manned at one point with up to 50 workers (Cruz y Bahamonde 1813: 91, note 1), did not possess its own specialised smithy.

Debris management

Working debris at certain millstone productions, such as at simple surface workings, dispersed exploitations and extended discontiguous quarries, was not a particular problem for millstone makers. Its accumulation in these workings did not hinder future work. At other sites, by contrast, in particular at bench, pocket, pit, trench, and subterranean quarries, debris grew rapidly and had to be continuously evacuated for the quarrymen to pursue their work. This could present a logistical problem for the quarrymen who were obliged to choose a spot so as to avoid having to move it a second time.

Moving debris involved investing the least effort possible. The most logical solution was to evacuate debris downhill, taking advantage of gravity for transport in baskets or in a wheelbarrow, and placing it in a heap. This was relatively simple in the case of bench and pocket quarries that were by definition situated on slopes.

In the case of trench quarries, debris was placed just outside the trench. Over time, contiguous heaps resulted in long cordons parallel to the trenches. For both pit and trench quarries, depending on their depth, paths had to be built to remove the debris. At times, the quarrymen erected drywalls that were backfilled to serve as ramps, both to enter and exit the workings.

In very deep quarries the millstone makers could have installed systems of ropes (possibly with pulleys) to lift sacks of debris. In very recent times, some mechanisms like capstans, as seen at the quarries in the Eifel (Germany) and Selbu (Norway), were used to facilitate moving heavy materials, probably including debris.

In some cases the workers backfilled sectors where millstone workings were depleted or halted. This is the case of several of subterranean exploitations at the Mont Vouan in France, recently the object of archaeological excavations (A. Belmont, dir.). Digging in modern conditions these backfilled sectors not only brings to light well-conserved tool marks under the debris, but permits archaeologists, by means of vertical stratigraphy, to study how the sector was backfilled.

All said, the lowly task of moving debris was probably reserved for the newer members of the working team. It is also possible to imagine that this was also carried out by women and children.

Residences and shelters

Making a single large millstone required several days of work. If the quarry was located far from town, then the millstone makers were obliged, at least during certain times of the year, to be lodged at night. If work was intensive and permanent, the workers had to be provided with some type of seasonal or permanent dwelling.

Through field work, we have observed that millstone makers built simple huts or hovels as shelters for short periods of time. Drystone hovels, with space for just a few men, were erected at the sites of El Lachar (J-2) and El Torcal (MA-1). At El Torcal there even appears to be a corral that, hypothetically, could have enclosed oxen, the animals used for the transport of the millstones. At subterranean sites, the cave itself could have served for workers to pass the night. The small post-framed house beside the quern quarry at the Roman site of Châbles-Les Saux in Switzerland (Anderson *et al.* 2003: chap. 8), in all of its simplicity, would have nonetheless provided a comfortable setting for the quern maker.

The situation at the Berrueco quarry (CA-8) was very different. We know from the narrative of Cruz y Bahamonde in the early 19th century, that this vast production counted 50 workers who were housed at the site (Cruz y Bahamonde 1813: 91, note 1). This is the only example in our study area where there is evidence of lodgings provided for the workers. There is no information, however, regarding the conditions or the rent the workers had to pay for the lodgings. The lodging situation of the other larger productions was different. Moclin (GR-1) and Cabra (CO-1) were very close to town. In these cases, permanent workers probably could return to their houses at night, whereas, itinerant workers probably were lodged in inns.

Millstone Transport

The concept of millstone transport comprised two basic steps. The first was that of removing the stone from its place of extraction to a staging point. It was at this second point, always near the quarry, where the first leg of a journey was initiated to either a workshop where the millstone was finished or to its final destination at the mill. This journey, depending on its distance, could comprise more than one means of transport: by land, by water or, more recently, by rail.

Moving millstones from their place of extraction was not simple. This depended on their size, the type of quarry and the surrounding terrain. A number of extraction sites were not necessarily accessible by animal-driven carts. For this, millstone makers built slipways and ramps using stone debris and rails or tracks with wood to facilitate removal of the stones. When draught animals could reach the extractive zones, they used sledges of different forms to drag the stone to the waiting cart. During this process the millstone makers, in order not to damage their product, wrapped the stones, for example, in reeds (Maestro Hernández 2011: 46).

At times, the transport to the final destination was very short so the same sledge used to haul the millstone out of the quarry could be used to drag it to the mill. There are even cases where a few men, assisted or not by animals, used the "rolling stone" method by inserting a wooden beam through its eye and rolling it like a wheel. These cases, attested orally on a number of occasions and illustrated by Gómez Ruíz (2003: 85, fig. 7), were certainly exceptions limited to transport over short distances.

Most millstone transport was undertaken by flat-bed carts pulled by either mules or oxen. This could be undertaken at times by the millstone makers themselves, who as farmers owned the animals. In other cases, they were transported by professional (*carreteros*).

In the case of longer distance transport, fluvial and maritime routes were an alternative used since ancient times. The 4th century shipwreck at El Sec (Arribas 1987), off the Bay of Majorca, was loaded with hopper-rubber querns and a few Morgantina models. Likewise, the second century BC shipwreck at Illa Pedrosa off the coast of Catalonia was transporting a cargo of 130 rotary querns (Vivar 2004). In our study area, no shipwreck with a cargo of millstone has been published. However, the presence of shell-rich biocalcarenite outcrops along the Bay of Cádiz at Trafalgar (CA-1) and Chipiona (CA-6) does suggest millstone transport by sea in ancient times and there are written records of maritime transport from both the early 16th (Fernández López 1982: 221, note 10) and 19th centuries (Ponce 1981).

Transport of millstones by rail into the south of Spain was a very late development, dating to the second half of the 19th century after completion of the rail network. Although there is no evidence, we suppose the larger producers of millstones of southern Spain profited from this new means of transport as did the quarries yielding construction material. Ironically, a consequence of this new rail transport was the arrival of imported French millstones, which would eventually undermine all the regional production centres.

14.9. The men behind the millstones

The profile of a millstone maker, his degree of specialisation and his place in society are difficult concepts to judge from the evidence at hand. The earliest saddle quern and rotary quern makers were first of all dedicated to farming and raising livestock. They certainly had an excellent knowledge of working rock, as seen through the long tradition of their stone tools, rock dwellings, and the building of defensive and funerary structures. Making querns, however, was far from their principal activity.

This situation changed during Roman times. Production on a large scale of sophisticated, standardised rotary querns and millstones for a growing population, provided millstone makers with work at least on a seasonal, if not a full-time basis. Working at Roman quarry sites required new skills in millstone making, in particular, that of extracting cylinders directly from bedrock (MQ-2a). At this stage, we can consider millstone makers as veritable specialists.

In the Middle Ages and during the Islamic domination we lose track of millstone makers. They certainly remained highly specialised workers due to the demand of large millstones for a growing number of watermills built along rivers and streams, and an ever developing system of irrigation ditches across the landscape. There may have been some quarries providing permanent work. But the lack of a dominant type of rock, such as volcanic materials in Roman times that were exported long distances, cut back the activity in specialised quarries and spread the work to a series of local or regional outcrops, possibly obliging the millstone makers to combine millstone work with other types of stonework or farming.

The situation after the fall of Islamic rule seems to be similar. Juan de Bargas, in the Province of Córdoba in the early 17th century, worked as both a millstone maker and a stone mason for construction projects (González Peralbo 2008). This duality was probably caused by the lack of regular millstone orders that obliged him and others like him to engage in other rock-related professions.

The situation in Contemporary times probably continued as in former times with millstone makers working only to meet specific orders. There is evidence, however, of the rise of certain specific production centres that had the capacity to retain professional millstone makers either full-time or at least large parts of the year. El Berrueco (CA-8) in Cádiz in the early 19th century lodged 50 workers (Cruz y Bahamonde 1813: 91, note 1), and a half century later had 23 men, split up in five different workshops (Madoz 1848, Vol. 11: 343).

These teams were divided into crews with a leader who saw to maintaining the rhythm and quality of production. These leaders may even have acquired the right to quarry concessions and thus would have gained profit from the workings. This profit and contact with the owners of the quarry, noblemen or clergymen, would have raised their social status.

The specialisation and intensity of work at these larger production sites would have brought with it occupational hazards like the immediate danger to the eyes and the limbs. Accidents at quarry sites were probably not uncommon. In the long term, and depending on the type of rock, was the lurking, silent killer of silicosis, a malady that could strike down a healthy man in a number of years.

14.10. Millstone quarry ownership and control

There is very little evidence of millstone quarry ownership and control in our study area. In general, and through time, we assume that modest quern and millstone exploitations for local consumption probably went unnoticed or ignored by the ruling bodies. Simple surface workings along riverbeds or taluses, for example, would have been extremely difficult to control. Isolated extractions in remote areas far from the urban centres also remained unnoticed. Larger production centres with a high potential of profit, did, however catch the eye of the ruling bodies.

These larger sites probably only drew the attention of the authorities since Antiquity. At this time, production at certain sites, in particular, volcanic quarries, attained a very high level, and the owners of the land where the quarries were found and/or the local political authorities surely coveted their control, like other potential sources of wealth, such as mines.

In the Middle Ages under Islamic rule, with the abandonment of volcanic exploitations, most production appear to have been undertaken at local and regional levels, profiting from a series of sedimentary rocks. It is reasonable to assume that small surface productions remained anonymous and did not receive attention. But larger productions, notably the true extractive exploitations of large dimensions, may have been under direct control of the ruling body or were obliged to pay tribute to the ruling bodies for their right of production and commercialisation.

After the Christian Reconquest, authority over production centres passed, as noted in certain legal codices and historical documents, under the direct supervision of the authorities. The *Fuero de Cuenca,* a set of laws dating to the late 12th century, assigning the transfer of property after the Christian conquest, is unequivocal on the question of ownership of these sites:

*"All the quarries, gypsum beds, **millstone quarries**, tile works, and also the perennial springs should be common property of **the council**. Whoever has a millstone quarry or any of these things mentioned previously on a property of his should sell it to **the council** for a double-sized property, and it becomes communal. If someone occupies it against another of the council, he should pay a hundred* aurei*"* (translation by J. Powers 2000: 57).

There are several other examples in old texts that exemplify the control of the authorities (nobility and the clergy) over millstone production, as well as other commercial activities. The council of Loja in 1502, for example, prohibited, by means of an oral proclamation, the extraction of millstones without the proper authorisation, under the threat of not only confiscation of the millstone but the oxen used to transport it (Pregón 1502, enero, 10. Loja,). At Llerena (BA-2) in Extremadura, a similar municipal ordinance dating to 1566, prohibited "foreigners" from extracting millstones from the local quarry, unless they, like the locals, paid the official tariff (http://manuelmaldonadofernandez3.blogspot.com.es/2010_04_01_archive.html). In 1501, the dispute between the councils of Antequera and Málaga over right to extract millstones in land under the authority of the council of Antequera, ultimately made it to the highest authorities at the time, the Catholic Monarchs (Isabel and Ferdinand) in Granada (Fernández López 1982: 222-223; AML, Leg. 49, p. 9. 1 cuartilla + 1).

In Contemporary times, the situation changed little. The dynasty of the Duque de Medina in the Province of Cádiz maintained not only control for several centuries over the vast quarry of El Berrueco (CA-8) (probably one of the larger productions in the south of the Iberian Peninsula), but control over a number of watermills. It is even documented that the family, in the early 19th century, received 18 millstones a year in exchange for the concession at the quarry (Cruz y Bahamonde 1813: 91, note 1). This was very profitable for the noble family because they not only received free of charge the best regional millstones, but could use them to replace the stones in the flour mills they owned.

The ownership of the Berrueco quarry owned by the noble family is probably typical of Contemporary times. These sites dominated the regional market. However, smaller productions, like the intermittent workings in the mountains of Palencia described by Maestro Hernández (2011), did not disappear. These modest centres offered a more economic alternative to the higher quality millstones from the larger centres. However, they certainly did not yield the highly prized white flour for white bread.

14.11. Millstone quarry chronology

Establishing the chronology of a millstone quarry is not a simple task. It is well established by examples in France and Switzerland, that a rock with excellent grinding properties could potentially have been exploited over a long period of time - centuries or more. This is seen in some cases at sites with a wide range of size of extractions from small rotary querns to large hydraulic millstones. Sites producing only one single, standardised product, however, were probably short-lived, as we suppose to be the case of the Roman Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2) sites in Almería.

There are a number of indicators that assist defining millstone quarry chronology. The first is written sources, such as historical and notarial archives, and geographical and geological texts. As useful as they are, these sources most often furnish only a *terminus* that reflects production at the moment the sources were penned, but do not record older and younger potential workings. The exception is when a site benefits from more than one written reference spread over a wide frame of time, such as El Torcal (MA-1), Loja (GR-2/3) and El Berrueco (CA-8), with texts ranging from the turn of the 15th to 16th centuries to the 19th century. In these cases, we are afforded a much more precise idea of their life span.

A second indicator of chronology is the morphometrics of 1) unfinished millstones abandoned at the site and/or 2) of the extraction hollows at the site. In general, large abandoned cylinders or extraction hollows, for example, tend to suggest recent quarry work, in the last few centuries, whereas small rotary quern extractions usually (although not always) suggest a dating from Antiquity or the Middle Ages. This information, in any case, is a starting point for a finer dating attained by combining other chronological indicators.

It must be noted that products abandoned at quarries, due to their unfinished nature, rarely bear typological elements (rynd cuttings or handle holes) from which finer datings can be obtained.

From measurements gathered at quarry sites, museum depositories and sparse millstone literature, we arrive at the following morphometric indicators that serve to determine chronological tendencies of millstone quarries in southern Spain.

1- Extractions ranging in diameter from 35 to 42 cm most often correspond to Iron Age and Roman querns. Iron Age models are usually smaller that Roman models. To complicate matters, Medieval querns, although generally larger than Iron Age and Roman models, are also known in this diameter range. The difference is that Iron Age and Roman querns, on the whole, are proportionally thicker than Middle Ages querns.

2- Thin, discoidal quern extractions 50 cm in diameter are associated, with a high degree of confidence, to the Middle Ages. Thicker models are animal fodder querns from Contemporary times.

3- The 60 to 90 cm diameter indicator is the most complex and covers all of the chronological periods. In general, Iron Age and Roman "drum" extractions in this range are for cylindrical mills that are as thick as they are wide. The tendency is for the Roman models to be slightly larger. Lower, discoidal models of this diameter are assumed to be either animal-driven or water-driven millstones ranging from the Middle Ages to Contemporary times. This 60 to 90 cm dimension range, independent of other indicators, is therefore not valid for dating.

4- Extractions with the diameter of 1,00 m to 1,50 m can date from at least the Late Middle Ages to Contemporary times. This wide range, although not very useful for dating, does permit discarding earlier periods.

Rock type is also an invaluable indicator because there are moments in times when certain rocks were more sought after than others. Volcanic materials (dacites, rhyolites, lamproites and basalts) are usually symptomatic of the Roman period, whereas, fine, white limestones are most often associated with very recent Modern or Contemporary productions.

At a level below that of written sources, morphometrics and rock type are a series of lesser chronological indictors: 1) place names, 2) geographical proximity of a quarry to a dated feature, 3) relative chronology and vertical stratigraphy, 4) extraction techniques and 5) oral information. All of these lesser indicators, applied independently, do not suffice to establish a reliable date for a quarry. Even so, they do serve to reinforce or corroborate the stronger, first-level chronological indicators (written sources, morphometrics and rock types).

To illustrate the chronology of the millstone quarries that we have identified in the south of the Iberian Peninsula, we have divided them into three assemblages represented in three tables.

Chronological assemblage 1 *(see table 11.2)*

This table represents the earliest quarries in chronological order based on their earliest phase of production. They range from Late Prehistory/Protohistory through Medieval times. These sites show workings of saddle querns, rotary querns, cylindrical mills, and small hydraulic millstones. Some, such as Rota (CA-3), Moclín (GR-1) and Castillo de Locubín (J-1), present later extraction phases certified through texts. The rock type indicator, especially the Roman volcanic productions, is essential to dating some of these sites.

Chronological assemblage 2a and 2b *(see tables 11.3a and 11 3b)*

These assemblages are established exclusively from written sources and are illustrated in two tables separated by a hiatus of about 30 years. The listing of these sites, like those of the first table, are founded on the earliest known extractive phase. Since these sites can be defined very precisely, this table (contrary to that of Table 11.2) is divided into columns representing centuries. The first assemblage (2a) (table 11.3a), corresponds broadly to the Modern period and presents the sites ranging from 1481 to 1794, and is divided into four subgroups (a, b, c, d).

Assemblage 2b, although a continuation of the first, designates the transition from Modern to Contemporary times (end of the 18th century). Most of the quarries of this second assemblage are identified in the dictionaries of Miñano (1826-1829) and Madoz (1845-1850). A few, from the end of the 19th or beginning of the 20th century, are dated from other written or oral sources.

Chronological assemblage 3 *(see table 11.4)*

This last table records the approximate dating of the remaining millstone quarries that do not benefit from any means of dating except for the size of their extractions (all over 1,00 m in diameter) that fall anywhere between the Middle Ages and Contemporary times. Only future work, both in the field and in historical archives, will provide more precise information as to the dating of these sites.

14.12. From quarry to mill: millstone distribution through the ages

In our study, we have attempted to dedicate a section to the question of quern and millstone distribution for each chronological period. The archaeological record, however, is very unbalanced from period to period. Therefore, we can only assume a degree of precision for the Roman period, based for the most part on quern and millstone finds in museums. The degree of precision for the Contemporary period is higher because it benefits from written sources. Distribution in the other periods, however, is highly speculative.

In general, the traditional divisions of "local, regional and long-distance" distribution are valid for our study area. For the Pre-Roman periods the little evidence points to local and a few regional productions. For the Roman period, based on a series of theoretical distances between potential quarry and find-spot, in particular those related to volcanic rocks, we can set the arbitrary limits of 20 km for local distribution, up to about 80 km for regional distribution, and over 100 km (sometimes attaining several hundred km) for long-distance distribution.

Long-distance trade of querns and millstones receded toward the end of Antiquity or beginning of the Middle Ages with the abandonment of volcanic millstones and a "return" to local and regional productions of sedimentary rocks. This could be related to volcanic rocks being less apt at milling at higher speeds of rotation at this time of a great expansion of watermills. However this is purely theoretical in our study area, because as we have stressed throughout this work, evidence of Roman and Early Middle Age watermills is practically nonexistent.

Hence, local and regional quarries would once again dominate millstone trade for centuries, until the Contemporary period. These were, for the most part, small productions that outfitted mills in surrounding areas. There were also most likely, during these times, quarries yielding products of higher quality that surely supplied mills farther away. Nonetheless, there is no evidence that any of these larger sites attained the commercial reach of volcanic quarries from Roman times.

Toward the middle of the 19th century, economic and infrastructure conditions made the south of Spain ripe for the influx, once again, of long-distance imports. At this time, it was no longer volcanic material, but siliceous rocks from a flourishing *meulières* in France, in particular, from the Brie region in the Parisian Basin. These French burrs, although very costly, would change the profession of milling, reducing the time invested in maintenance and dressing, and increasing considerably the yield and quality of flour - and providing a better tasting and finer, white bread.

14.13. From stone to bread

Dust and grit in the bread is as old as bread itself. This resulted in part from not cleaning the grain correctly (Agustí 1722: 187) and, in part, from minute rock particles that fell into the flour during grinding. It is a problem that is recognised in our study area since at least the 16th century (Gómez Ruíz 2003: 31). All stones, to a certain degree, were culprits of this grit that wore down people's teeth. Rock dust was especially prevalent after the dressing of millstones (Agustí 1722: 187), a routine that had to be undertaken frequently, at times on a daily basis. Since at least Late Medieval times, there is evidence of a desire and measures taken to free bread of these "impurities".

In many old texts, there are terms or expressions associated with quarries, millstones, flour and bread that have different meanings. *Piedra blanca*, is synonymous with both white-coloured stone and the upper stone (runner) of the millstone pair. The word for "dark" (*bazo* or *baza*, *baxo*) denotes both dark-coloured stones, as well as the lower stone of the pair. These connotations, as we have noted, go beyond simple definitions of stones, quarries, flour and bread and have social and economic implications. White bread (*pan blanco*) was traditionally associated with the noble class and the clergy, whereas dark bread (*pan moreno, bazo, baxo*) was the bread of the lower classes.

In spite of all the skill and experience of a miller, a white flour could not be attained with just any cereal or any millstone. The cereal that lent itself best to producing white bread, due to its starchy endosperm, was bread wheat, a grain that was readily available in the south of Spain.

A prerequisite to obtain white bread is to separate the white endosperm from the bran and germ. This depended greatly on the miller's experience and ability, who determined the quantity of water to add to the grains previous to grinding to facilitate the separation of the bran from the endosperm. He also controlled the amount of "light" between the upper and lower stones so as to ensure a coarser or finer grinding. He also decided when to accelerate or slow down the rotation of the stones, and when to halt grinding to remove and re-sharpen the stones. Finally, the miller determined if the flour needed a second round of grinding, and the choice of the sieves for sifting to attain the desired calibre of flour.

In spite of all the miller's abilities, white bread could not be attained by just any type of rock. The advantage of the bright white limestones, such as those from Moclín (GR-1) in Granada and Berruecos (CA-8) in Cádiz, and certainly that of Colmenar de Oreja (M-2) in Madrid, is that the grit released into the flour was white and therefore would not have affected the colour of the bread (Belmont 2011: 15). In this sense, the advantage of grinding with bright, white rocks was not the absence of stone dust in the flour, but the perception of its absence.

14.14. Final comments and perspectives

The principal focus of this research is to tell the story of the procurement of querns and millstones in quarries from Protohistory to Modern times, a project that has never been undertaken in the south of Spain. The term "Modern" in the title of this work, is to be interpreted in its broad sense, corresponding to the transition from the 19th to the 20th century. This is the period when the Iberian millstone production industry waned, initially, as a result of the introduction of silicious French Burrs. These *meulas francesas,* still seen decorating public spaces throughout Spain today, were a cut above any millstone produced elsewhere in Spain (and the rest of Europe). The ultimate demise of the Iberian millstone industry came to pass with the introduction in the 20th century of the steel roller, which would inexorably precipitate the end not only of the quarries, but the traditional milling industry and the profession of millers.

As we have stated on a number of occasions, much research still remains to be undertaken on millstone quarries and millstones in southern Spain. We have only been able to "survey" about a third of the sites that we have identified (and there are certainly still more to be found). It must be noted that these visits have most often been too short to document the sites accurately.

Furthermore, in the perspective of establishing a future chrono-typology of millstone quarries and their products, there is the need of developing coordinated research objectives, similar to what the recent projects undertaken by the "Groupe Meule" in France or the "Norwegian Millstone Landscape" in Norway, that have combined studies of quarries in the field, studies of millstones in museums, research in historical archives with a programme of petrographical analyses. Painting a more precise portrait of the newest members of the European volcanic millstone quarry "club", the Southeastern and the Calatrava Volcanic Provinces, is essential to research in a larger framework.

Like many other features of cultural heritage, these sites deserve due recognition and should be recorded and mapped, and authorities should be notified of their existence so that they may be afforded the same protection and recognition as any other monument of cultural heritage. All too often these spectacular quarries with their towering, tubular faces have been neglected, or even worse, destroyed. It must be noted that no millstone quarry in our study area has benefitted from a real valorisation with detailed explanatory panels explaining the different stages of the workings.

Hopefully, in spite of the difficult economic conditions that the present society is experiencing, this new area of research will not be dismissed, as happened to the brilliant millstone research initiated by Fernando de Avilés in the 1940s (Berrocal 2007). It must be recognised that the subject of millstone production is essential to the understanding of the history of nutrition of man. It is our desire that the recent international round table meeting in Arbeca, Catalonia, bringing together researchers from Spain and France to discuss Iron Age millstones and quarries, be a starting point in this direction.

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Chap. 1:

Fig. 1.4: Photograph from c. 1915 of the quarry of Montjuïc (Barcelona) from the blog of Ana Ma Ferrin, http://amf2010blog.blogspot.com.es/2012/03/gaudi-y-la-piedra-un-magico-acuerdo.html) [accessed March 10, 2013].

Fig. 1.5: Montjuïc quarry: http://barcelonaimatgesambhistoria.blogspot.com.es/2012_01_01_archive.html

*Fig. 1.6: Photograph dating to March 1933 of millstone makers (*moleros*) at the quarry of Brañosera in the mountains of Palencia (from Cuevas Ruiz 2006).*

Fig. 1.8: Reconstruction of a Moorish donkey-driven olive oil mill dating to the 15th century, Nigüelas, Granada. Photograph by Eve Andersson.

Fig. 1.9: Rotary sharpening stone (1808-1812). Painting by Francisco de Goya. Exposed in the Budapest Museum of Fine Arts.

Fig. 1.11: Abandoned granite quern extraction or property boundary near Ávila (Ávila) (from the blog of M. Serna Martínez; http://terraeantiqvae.com/profiles/blogs/el-medievo-a-las-puertas-de-vila#.UV0wl45FfuE).

Chap. 2:

Fig. 2.1: Cover pages of the geographical and historical dictionaries known as "the Madoz" and "the Miñano": a) Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar, 16 vol., 1845-1850; b) Diccionario Geográfico y Estadístico de España y Portugal, 11 vol., 1826-1829.

Fig. 2.2: Extract and detail of the Padul (Granada) entry to the Census of the Marqués de Ensenada. El Catastro del Marqués de Ensenada en el Antiguo Reino de Granada, Instrumentos de Descripción, Archivos 16, A.H.P.G (in CD format).

Chap. 3:

Fig. 3.2: Examples of saddle querns of various lithologies. a) Late Neolithic calcareous sandstone quern from the site of Los Pensadores (Granada), excavation T. Anderson, unpublished; b) Chalcolithic garnet mica schist from Las Rajas (Granada) excavation T. Anderson, unpublished; c) Early Bronze Age garnet mica schist querns from Fuente Álamo (Murcia); d) Iron Age sandstone and conglomerate querns from Numantia (Soria); e) granite querns from the Early Iron Age site of Cancho Roano (Badajoz) (photographs a-c by author; photograph c from http://www.elargar.com/caracterizacion/Artefactos/Instrumentos/; photograph e from http://extremosdelduero.blogspot.com.es/2011/12/edificio-protohistorico-de-la-mata.html).

Fig. 3.4: Examples of rotary handquerns attributed to the Iron Age. a-b) Upper stone (ø: 32 cm) and lower stone (ø: 34 cm) from Ventorros de San José (Granada), possibly a pair; b) upper stone with lugs with vertical slits (Alcalá la Real, Jaén); upper stone (ø: 38 cm) with inverted "keyhole" handle cuttings (Jódar, Jaén); and e) top and side view of an upper stone with lug and inverted "keyhole" cutting (Cerro de la Cruz, Almedinilla, Córdoba). Petrography: a-c) porous limestone; d) probably conglomerate; e) granite. I thank E. Kavanagh for the photograph of the Cerro de la Cruz quern.

Fig. 3.5: 1) Roman quern upper stone (ø: 39 cm) (photograph by the Museo Arqueológico de Linares, Jaén; 2) Example of a "sombrero" type lower stone (ø: 36 cm), Museo Municipal de Úbeda. Both are of volcanic rock.

Fig. 3.9: Rotary querns from the 1981 excavation of the Medieval settlement of El Castillejo, Montefrío (Granada) dating from the 9th to the 12th century (Motos Guirao 1987: 480). a) Upper stone with handle hole and lower rynd cutting, ø c. 38 cm; b) upper stone with no rynd cutting; c) lower stone; and d) upper stone with handle and rynd cutting of a very small hand-quern (photographs by T. Anderson; the sections from the original drawings from Motos Guirao 1987, plates I-III).

Fig. 3.11: Schema of the Contemporary (20th century) handmill from Cubo de la Sierra (Soria) (drawing by T. Anderson, from Pascual et al. *2010, 10, fig. 5).*

Fig. 3.14: Iron Age "travertine" mill in situ *at the Cerro de la Cruz (photo a from http://www.rutasconhistoria.es/loc/poblado-ibero-el-cerro-de-la-cruz).*

Fig. 3.16: Volcanic ring catillus *from the Roman city of* Castulo *(Jaén). The type of rock of the lower stone (not the original pair) has not been determined. ø: 64 cm (photograph, Domus, Linares museum, inv. no. CE01430_R).*

Fig. 3.18: Photograph c, Domus http://www.juntadeandalucia.es/culturaydeporte/WEBDomus/fichaCompleta.do ?acron=MAEGR&musid=9&ninv=CE14119&volver=portal&k=CE14119&tipoBusqueda=simple
.
Fig. 3.20: Representations of Pompeian millstones on Roman lamps. a-b) Bilbilis*, Zaragoza (from Amaré 1988, p. 83-84, fig. 152-153; c) Murcia (from Amante 1988, p. 227, pl. IV, 72).*

Fig. 3.21: Pompeian mill from Mazarrón (Murcia). The lower stone and podium are reconstructed (photograph Museo Arqueológico de Murcia).

Fig. 3.23: Extract from the Codex of pseudo Juanele Turriano (approx. 1595) depicting a tahona *(animal-driven grain mill) (from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

*Fig. 3.24: View of part of the animal-driven flour mill (*tahona*) in the castle of Calatrava la Nueva (Aldea del Rey, Ciudad Real) (photograph left http://patrindustrialquitectonico.blogspot.com.es/2011/08/un-molino-del-siglo-xii-es-las-nueva.html; photograph right by T. Anderson).*

Fig. 3.27-1: Engraving from 1842 entitled Molinos Árabes de la Mina en Alcalá de Guadaira by Genaro Pérez de Villaamil. The scene is the mill house of a subterranean watermill under the town of Alcalá de Guadaira (Seville) (from http://sevillalegendaria.blogspot.com.es/2013/05/los-canos-de-carmona-agua-e-historia.html).

Fig. 3.28: Extract from the Codex of pseudo Juanele Turriano (approx. 1595) depicting an aceña *(vertical wheel grain mill) (from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

Fig. 3.29: Extract from an engraving by the Flemish artist Van den Wyngaerde (1567) with a view of the city of Córdoba. The arrows point to the waterwheels of the aceñas *in the Guadalquivir River (original illustration in the Victoria and Albert Museum of London).*

Fig. 3.30: Extract from the Codex of pseudo Juanele Turriano (approx. 1595) depicting a rodezno *(horizontal wheel grain mill) (from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

Fig. 3.31: Drawings from the Catastro del Marqués de Ensenada (1750-1754) of the towns of Nivar and Viznar (Province of Granada) with the location of the rodezno *watermills. These drawings supplement the answers of a questionnaire and illustrate the principal features of the towns such as mills, churches, houses, surrounding farms, irrigation ditches (*acequias*) and landmarks (crosses). El Catastro del Marqués de Ensenada en el Antiguo Reino de Granada, Instrumentos de Descripción, Archivos 16, A.H.P.G. (in CD format).*

Fig. 3.33: Drawing of the windmills of Belmonte (Cuenca) by Van de Wyngaerde (1563). The work is in the Victoria and Albert Museum, London (from Ibáñez 2003: 75).

Fig. 3.34: Photograph by Jean Dableda of the town of Torrevieja, Alicante in the late 19th century (photograph from http://franciscorebollo.blogspot.com.es/2011_09_01_archive.html).

Fig. 3.35: Examples of windmills (Cartagena, Murcia and Cabo de Gata, Almería) in southeastern Spain driven by vanes with triangular sails (photograph left by Torres Ros, http://www.forocartagena.com/t800-molinos-de-viento-y-arquitectura-del-campo-de-cartagena; photograph right Cabo de Gata, Nijar, Almería by T. Anderson).

Chap. 4:

Fig. 4.1. Map of the principal geological zones of Iberia (after Farias et al. 1987). A black and white version of this map appeared in Anderson & Scarrow 2011: 261.

Fig. 4.2: Detailed map of the principal geological formations of the Bétic range (after Martín Algarra 2004). A black and white version of this map appeared in Anderson & Scarrow 2011: 261.

Fig. 4.5: Detail of the SE Spain volcanic district with the location of the reputed Roman quern and millstone quarries (adapted from Cambeses 2010: 8, fig. 1.3).

Chap. 5

Fig. 5.5: Photograph dating to 1933 of moleros *(millstone makers) at the millstone quarry of Brañosera (Palencia) in northern Spain (photograph from Cuevas Ruiz 2006).*

Fig. 5.6: Examples of tools of direct percussion. Left: Engraving from Antiquity of a quarryman with his pick, Kruft, Kr. Mayen (Germany) (photograph from Röder 1957, Plate 21, 1). Right: Scene of a quarryman cutting or shaping a block on a capital of a column of the western entrance to the church of San Miguel de Biota (Zaragoza), 12th century (photograph by Ray Escámez Rivero, flicker, http://www.flickr.com/photos/adfinem/6849827592/).

Fig. 5.14: Examples of vertical extractions at the site of El Campillo Viejo (HU-1) (photographs by A. García Veiga).

Fig. 5.23: Schema of the technique of splitting a quern cylinder directly with a pick, avoiding the use of wedges

(from Anderson et al. 2003: 49, fig. 44, drawing by A. Pulido).

Fig. 5.24: Examples of tool marks on the quarry floor of the quern quarry of Châbles, Fribourg (Switzerland) (from Anderson et al. *2003: 51, fig. 52). We thank Jean-Claude Bessac for pointing out this significant detail.*

Fig. 5.26: Reconstruction of the technique of detaching an angular block from the quarry floor for millstone production (drawing by T. Anderson based on a photograph from http://burgess-shale.rom.on.ca/en/transcripts/slideshow_1998.html).

*Fig. 5.33: Example of a "*chaîne opératoire*" of quern fashioning from angular blocks based on observations at the quarry site of Portus (Collonge-en-Charollais, Saône-et-Loire (from Jaccottey* et al. *2011: 194, fig. 39).*

Fig. 5.38: Cylindrical roughout from the true extractive quarry of Châbles, Fribourg, Switzerland. The pecks (no. 3) on the upper surface are from single pointed chisel strikes, whereas the thin vertical lines on the edge (no. 4) are multiple contiguous chisel strikes. The "paunch" (bourrelet) indicating work on one half at a time is visible to the bottom left of each representation. The larger diagonal lines, no. 1, are the original extraction pick marks and no. 2 are the splitting cavities (from Anderson et al. *2003: 55, fig. 61, drawing by T. Anderson).*

*Fig. 5.39: Example of fashioning a sandstone (*grès coquillier*) rotary quern with hammer and chisel at the site of Châbles, Fribourg, Switzerland. One half was fashioned before turning the cylinder around to fashion the second half, resulting in a "paunch" along the base (from Anderson* et al. *2003: 54, fig. 60, drawing by A. Pulido).*

Fig. 5.46: Schema of the two types of composite millstones proposed in the pseudo Juanele Turriano Codex. The schema to the left with five stones is more solid, according to the author, than the model to the right (from pseudo Juanelo Turriano - 1996,Vol. III: 351, fig. 204 1996. *http://issuu.com/juaneloturriano/docs/21librosingeniosymaquinastomo_iii.*

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Fig. 6.18: Photograph of Miraflores de la Sierra (M-5) by Fernando Colmenarviejo.

Fig. 6.19: Photographs of El Campillo Viejo a and b by Alonso García Veiga;

Chap. 8:

Fig. 8.1: Plan of the Gallo-Roman site of Châbles-Les Saux dating to the 1st-2nd century AD (Canton of Fribourg, Switzerland). The a) millstone quarry and the b) smithy are circled. The study of this excavation revealed a tight link between the smithy and the quarry (from Anderson et al. *2003: 34, fig. 23). The other noteworthy features are the c) road and d) house interpreted as the residence of the quarryman.*

*Fig. 8.9: Plan of part of the Gallo-Roman site of Châbles-Les Saux dating to the 1st-2nd century AD (Canton of Fribourg, Switzerland). The rectangular house (*bâtiment est/east house*), built with wood, is between the road and the quarry. This modest structure is interpreted as the residence of the quarryman (from Anderson* et al. *2003: 196, fig. 241, drawing by T. Anderson).*

Fig. 8.13: Drawing from the pseudo Juanelo Turriano codex (c.1595) of a quarry cart driven by mules (from Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).

Fig. 8.14: Modern flatbed quarry cart from Extremadura (from Martín Galindo 2006: 849).

Fig. 8.15: Reconstruction of an oxen-drawn cart for the transport of millstones and other heavy production, based on information from the region of Navarra (from Pascual et al. 2011: 250, fig. 25, drawing by J. Castro).

Fig. 8.16: Examples of recent "V" shaped rastra *sledges designed to transport heavy loads (photo a from http://cuentoquenoescuento.blogspot.com.es/2012_02_01_archive.html; photo B from http://espanolinternacional.blogspot.com.es/2008/03/el-transporte.html).*

Fig. 8.17: Example of a narria *(from Pascual Mayoral et al. 2011: 249, fig. 23; drawing by Javier Castro).*

Fig. 8.18: Reconstruction of a scene of moving a millstone by means of the "rolling stone" technique (from Gómez Ruíz 2003: 85, fig. 7).

Fig. 8.19: Example of a rutted road cut through a conglomerate embankment. This road is near the quern and millstone quarry of the Puerto de la Cadena (MU-1) (from http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/).

Fig. 8.20: Scene at the loading platform of the train station of Gerena (Seville), where granite blocks were loaded onto wagons. Oil rollers and millstones probably also benefitted from this means of transport (photograph from http://lafactoria-cuencaminera.blogspot.com.es/2010_12_01_archive.html).

Fig. 8.21: Huelva train station towards the end of the 19th century with 5 millstones in transit. Behind the upright example (to the left), are three others. The stone to the right, under the sitting official, appears to have a fracture

along its lower rim. The absence of iron girth bands reduces the likelihood that they were composite French Burr imports. The Huelva-Zafra rail line was built between 1867 and 1900. The station is by the port, as seen by the boats in the background to the right (photograph from http://lafactoria-cuencaminera.blogspot.com.es/2011/06/casas-espanolas-al-borde-de-un.html).

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Fig. 9.1: Photograph dating to 1933 of moleros *(millstone makers) at the quarry of Brañosera (Palencia) in northern Spain (photograph from Cuevas Ruiz 2006).*

Fig. 9.2: Photographs of the working crews of the quarries of Montjuïc (Barcelona) and Gerena, Seville (SE-7). (Montjuïc from http://amf2010blog.blogspot.com.es/2012/03/gaudi-y-la-piedra-un-magico-acuerdo.html); photograph of Gerena from Acuña Carabantes 2004.

Fig. 9.3: Scene of workers from the 1920s from a granite quarry (building blocks or paving stones) in the area of Gerena, Seville, an district known to have produced millstones. In the background, to the left, is what appears to be a child (from Acuña Carabantes 2004).

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Fig. 10.5: View of the alignment of 255 millstones in the Fuentelárbol (Quintana Redonda, Soria) (photograph by P. Pascual and P. García).

Chap. 11:

Fig. 11.4: View of taking the measures of the extraction hollows of Rambla Honda (AL-3a) (photograph by. F. Martínez).

Fig. 11.5: Line graph of the diameters of 151 quern and millstone hollows measured in cm (from Martínez et al. *2011). Four diameter groups stand out at this site: a) from 40 to 50; b) from 80 to 95; c) from 105 to 120; d)a final group between 130 and 140 is more modest.*

Fig. 11.10: Cerrp de la Cruz: Photograph left: http://www.rutasconhistoria.es/loc/poblado-ibero-el-cerro-de-la-cruz

Fig. 11.19: Example of a small unfinished quern extraction at Ibi (A-2). The quern is difficult to date. The proportion of its diameter to its width suggests a Roman or Iron Age date (photograph by Ágata Marquiegui).

Fig. 11.23: Quern extraction in the heart of an abandoned millstone extraction at the quarry of Puerto de la Cadena (MU-1) (from : http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/).

Fig. 11.24: View of a tubular face at the quarry of Montesa (V-2) (photograph by J. García Cerdá).

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Fig. 12.5: Quern and millstone from Jódar, Jaén. The quern to the left is a conglomerate (Ø: 40 cm); the stone to the right is a granite (Ø: 52 cm) (photograph by Ildefonso Alcalá, Museum of Jódar).

Fig 12.15: Volcanic Pompeian hourglass catilli from the Museo de Bellas Artes de Córdoba and from the Museo Arqueológico de Murcia (photograph by the Museo de Murcia).

Fig 12.16: Pompeian hourglass catilli *from the Museum of Mellilla (photograph by Museo de Melilla).*

*Fig 12.18: Example of a cylindrical ring-*catillus *from the Roman city of* Castulo *(Jaén),ø: 64 cm (photograph Linares museum, inv. no. CE01430_R).*

Chap. 13:

Fig. 13.1: Extract of a sermon of the Dominican Friar Domingo Baltanás from Seville.

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Province of Ciudad Real

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Annexes

1 List of millstone quarries

2 Spanish-English glossary

3 Extracts from the dictionaries of S. Miñano and P. Madoz

4 Pinilla de Jadraque: quarry to mill distances

Annex 1
List of millstone quarries

Province	Municipality	Name	Code	Field confirmed	Confirmed by photography	Indicated in text, not confirmed in field	Supposed
Granada	Moclín	Canteras	GR-1a	X	-	-	-
Granada	Moclín	Las Pedrizas	GR-1b	X	-	-	-
Granada	Loja	Cerro de Fuensanta	GR-2	X	-	-	-
Granada	Loja	Camino del Calvario	GR-3	X	-	-	-
Granada	Loja	La Merced 1	GR-4a	X	-	-	-
Granada	Loja	La Merced 2	GR-4b	X	-	-	-
Granada	Loja	La Merced 3	GR-4c	X	-	-	-
Granada	Zagra	La Atalayuela	GR-5	X	-	-	-
Granada	Alhama de Granada	Fuente de los Morales	GR-6	X	-	-	-
Granada	Padul	Barranco de los Guillares	GR-7	X	-	-	-
Granada	Los Guájares	Los Mochos	GR-8	X	-	-	-
Granada	Motril	Playa de Carchuna	GR-9	X	-	-	-
Granada	Vélez de Benaudalia	Barranco de la Piedras	GR-10	X	-	-	-
Granada	Caniles	Rambla de las Canteras	GR-11	X	-	-	-
Granada	Pinos Puente	Cantera de Zujaira	GR-12	-	-	-	X
Granada	Otívar		GR-13	-	-	X	-
Granada	Ugíjar	Las Canteras	GR-14	-	-	X	-
Almería	Níjar	Cerro de Limones	AL-1	X	-	-	-
Almería	Níjar	La Hoya del Paraíso	AL-2	X	-	-	-
Almería	Albox	Cantera de la Rambla Honda	AL-3a	X	-	-	-
Almería	Albox	Los Leonardos	AL-3b	X	-	-	-
Almería	El Ejido	Guardias Viejas	AL-4	X	-	-	-
Almería	Alcolea	Barranco Baena-Pedreros	AL-5	-	-	X	-
Almería	Bayárcal	Barranco de Palancón	AL-6	-	-	X	-
Almería	Sorbas	Los Loberos	AL-7	-	-	X	-
Almería	Adra	Cerro el Chispas	AL-8	-	-	X	-
Almería	Vera		AL-9	-	-	X	
Almería	Níjar	El Barronal	AL-10	-	-	X	
Almería	Níjar	Rodalquilar	AL-11	-	-	-	X
Jaén	Castillo de Locubín	Las Canteras	J-1	X	-	-	-
Jaén	Jimena	El Lachar	J-2	X	-	-	-
Jaén	Huelma-Solera	Las Canteras	J-3	-	-	X	-
Jaén	Cambil	Arbuniel – Los Batanes	J-4	-	X	-	-
Jaén	Andújar	Morales	J-5	-	-	X	-
Jaén	Andújar	El Pedroso	J-6	-	-	X	-

Province	Municipality	Name	Code	Field confirmed	Confirmed by photography	Indicated in text, not confirmed in field	Supposed
Jaén	Linares		J-7	-	-	X	-
Córdoba	Cabra	Cantera de los Frailes	CO-1	X	-	-	-
Córdoba	Cabra	Los Cortaores	CO-2	X	-	-	-
Córdoba	Carcabuey	Cudillas	CO-3	X	-	-	-
Córdoba	Priego de Córdoba	Vega de los Morales	CO-4	-	X	-	-
Córdoba	Baena	Molino de la Piedra	CO-5	-	-	X	-
Córdoba	Baena	Monte de Iscar (Izcar)	CO-6	-	-	X	-
Córdoba	Córdoba	Santa Ana de Albaida	CO-7	-	X	-	-
Córdoba	Posadas	Cantera Honda	CO-8	-	X	-	-
Córdoba	Córdoba	Los Arenales	CO-9	-	-	X	-
Córdoba	Bélmez	La Pedrera, Arroyo Albardado	CO-10	-	X	-	-
Córdoba	Villanueva de Córdoba	Piedras Moleras	CO-11	-	-	-	X
Córdoba	Córdoba	El Partiarca	CO-12	-	X	-	-
Córdoba	Hornachuelos		CO-13	-	-	X	-
Córdoba	Montoro		CO-14	-	-	X	-
Córdoba	Almendinilla		CO-15	-	-	-	X
Málaga	Anterquera	El Torcal Bajo	MA-1	X	-	-	-
Málaga	Teba	El Tajo	MA-2	X	-	-	-
Málaga	Alhaurín el Grande	Las Canteras	MA-3	-	-	X	-
Málaga	Coín	Sierra Gorda	MA-4	-	-	X	-
Málaga	Guaro		MA-5	-	-	X	-
Málaga	Alozaina	Mulera	MA-6	-	-	X	-
Málaga	Málaga	El Jabonero	MA-7	-	-	-	X
Málaga	Casares	Sierra de Utrera Karst	MA-8	-	-	X	-
Cádiz	Barbate	Bahía de Trafalgar	CA-1	X	-	-	-
Cádiz	Tarifa	Punta Camarinal	CA-2	-	-	-	X
Cádiz	Rota	Bahía de Cádiz	CA-3	X	-	-	-
Cádiz	Rota	Playa de Aguaduce	CA-4	-	-	-	X
Cádiz	Rota	Roa Martín	CA-5	-	-	X	-
Cádiz	Chipiona	Playa de las Canteras	CA-6	X	-	-	-
Cádiz	Tarifa	Isla de la Paloma	CA-7	-	-	X	-
Cádiz	Medina Sidonia	El Berrueco	CA-8	X	-	-	-
Cádiz	Medina Sidonia	Pila de Casares	CA-9	X	-	-	-
Cádiz	Alcalá de los Gazules	Peña Arpada	CA-10	X	-	-	-
Cádiz	Ubrique	Salto de la Mora	CA-11	-	-	X	-
Cádiz	Benaocaz	El Esparragal	CA-12	-	-	X	-
Cádiz	San Roque	Las Canteras – Guadalquitón	CA-13	-	-	X	-
Seville	Almadén de la Plata	Arroyo de la Calzadilla 1	SE-1a	X	-	-	-
Seville	Almadén de la Plata	Arroyo de la Calzadilla 2	SE-1b	X	-	-	-
Seville	El Pedroso	El Castillejo	SE-2	X	-	-	-
Seville	Lora de Estepa	El Hacho	SE-3	X	-	-	-
Seville	Casariche	Cerro Bellido	SE-4	X	-	-	-
Seville	Alanís		SE-5	-	-	X	-
Seville	Villanueva de San Juan		SE-6	-	-	X	-
Seville	Gerena		SE-7	-	-	-	X

Province	Municipality	Name	Code	Field confirmed	Confirmed by photography	Indicated in text, not confirmed in field	Supposed
Huelva	El Campillo	Umbría del Hornillo	HU-1	-	X	-	-
Huelva	Linares de la Sierra	El Prao de Abad I-II	HU-2	-	X	-	-
Huelva	Linares de la Sierra	Las Malenas I-II	HU-3	-	X	-	-
Huelva	Aracena	La Obra Pía	HU-4	-	X	-	-
Huelva	Puebla de Guzmán	Cerro del Águila	HU-5	-	-	X	-
Huelva	Zalamea la Real		HU-6	-	-	X	-
Huelva	Aroche	Fuente de la Aliseda	HU-7	-	-	X	-
Huelva	Almonaster la Real	Los Molares	HU-8	-	-	X	-
Murcia	Murcia	Puerto de la Cadena	MU-1	X	-	-	-
Murcia	Mazarrón	Cabezo de la Oliva	MU-2	-	-	X	-
Murcia	Murcia	Cantera de los Porches	MU-3	-	X	-	-
Murcia	Fortuna	Sierra de los Baños	MU-4	-	X	-	-
Ciudad Real	Almodóvar del Campo	Sisapo-Bienvenida	CR-1	X	-	-	-
Ciudad Real	Bolaños de Calatrava	Cantera de las Herrerías	CR-2	X	-	-	-
Ciudad Real	Chillón		CR-3	-	-	X	-
Ciudad Real	Alcázar de San Juan	Pedrizas de Piédrola	CR-4	-	-	X	-
Ciudad Real	Granátula de Calatrava	Las Canteras	CR-5	-	X	-	-
Albacete	Fuentealbilla	El Molar	AB-1	-	-	X	-
Albacete	Hellín	Pitón de Cancarix	AB-2	-	-	-	X
Toledo	Torrecilla de la Jara		TO-1	-	-	X	-
Toledo	Las Ventas con Peña Aguilera		TO-2	-	-	X	-
Cuenca	Portilla	Los Molares	CU-1	-	X	-	-
Guadalajara	Brihuega		GU-1	-	-	-	X
Guadalajara	Pinilla de Jadraque	Monasterio de San Salvador	GU-2	-	-	-	X
Guadalajara	Cifuentes	Ruguilla	GU-3	-	-	-	X
Guadalajara	Sigüenza	La Cuerda	GU-4	-	X	-	-
Guadalajara	Sienes	Tobes	GU-5	-	-	-	X
Guadalajara	Corduente		GU-6	-	-	-	X
Guadalajara	Castilnuevo		GU-7	-	-	-	X
Guadalajara	Montarrón	Los Morales (Los Molares)	GU-8	-	-	-	X
Guadalajara	Cobeta	Barranco de Arrandilla	GU-9	-	X	-	-
Alicante	San Fulgencio	Sierra del Molar	A-1	-	-	X	-
Alicante	Ibi	Barranco de los Molinos	A-2	-	X	-	-
Valencia	Canals	Les Moles	V-1	-	X	-	-
Valencia	Montesa	La Mola	V-2	-	X	-	-
Castellón	Soneja	Los Arenales	CS-1	-	X	-	-
Castellón	Nules, Judicial District		CS-2	-	-	X	-
Badajoz	Alconera	Las Pedreras	BA-1	-	-	X	-
Badajoz	Llerena	El Molar	BA-2	-	-	X	-
Badajoz	Llera		BA-3	-	-	X	-

Province	Municipality	Name	Code	Field confirmed	Confirmed by photography	Indicated in text, not confirmed in field	Supposed
Badajoz	Salvaleón		BA-4	-	-	X	-
Badajoz	Jerez de los Caballeros		BA-5	-	X	-	-
Badajoz	Zafra (Judicial District)		BA-6	-	-	X	-
Badajoz	Mérida		BA-7	-	-	v	X
Cáceres	Villar de Plasencia		CC-2	-	-	X	-
Cáceres	Villar de Plasencia		CC-3	-	X	-	-
Cáceres	Bohonal de Ibor	Molino Gualija	CC-4	-	X	-	-
Cáceres	Guijo de Galisteo	Dehesa Boyal	CC-5	-	X	-	-
Cáceres	Logrosán	Sierra de San Critóbal	CC-6	-	-	X	-
Madrid	El Berrrueco		M-1	-	X	-	-
Madrid	Colmenar de Oreja	Las Canteras	M-2	-	-	X	-
Madrid	Colmenar Viejo		M-3	-	-	X	-
Madrid	Chapinería		M-4	-	-	X	-
Madrid	Miraflores de la Sierra		M-5	X	X		

Annex 2
Spanish-English glossary

Molino : Mills

Molino vaivén: saddle quern

Molino rotatorio manual: rotary quern

Tahona: animal driven flour mill (also bakery)

Aceña: watermill with vertical water wheel

Rodenzo: watermill with horizontal water wheel

Almazara: olive oil mill

Muela: Millstone

Muela: quern or millstone. This term (like the French *meule*) covers all the types of millstones from the earliest saddle quern to the most recent French burr import

Not to be confused with the following:

Muela: tooth (molar)

Muela: hill with a flat top

Muela or almorta: a legume (*Lathyrus sativus*), is an indigenous plant, especially in the north of Spain, that was consumed by humans in the 19th century

Francesas: literally "French", refers to siliceous millstones imported from quarries in France (such as La Ferté sous Jouarre). Used with *muelas* and *piedras*

Grano: millstone specifically for *Tahonas* animal-driven millstones. Possibly a local term at the Berrueco (CA-8). No reference to this term has been identified with millstones in any dictionaries

Volandera: upper stone

Piedra blanca: upper stone

Corredera: upper stone

Piedra móvil: upper stone

Solera: lower stone

Yusera: lower stone

Bermeja: lower stone

Piedra baza: lower stone

Cantera: quarry

Pedrera: quarry

Tajo: quarry, mine

Molera: millstone quarry

Cantero: quarryman

Picapedrero: quarryman

Pedrero: quarryman

Molero: millstone maker or millstone merchant

Extractive terminology

sacar: extract

extraer: extract

senos: hollows

nidos: hollows

Rocks types:

Almendrilla (*piedra*): conglomerate (pudding stone) with almond-sized clasts

Berroqueña (*piedra*): term usually designates granite

Blanca (*piedra*): term designates as times white limestone rock and white (biotite) granite. It also designates the upper stone

Bravía (*piedra*): coarse stone

Jabaluna (*piedra*): a type of limestone (not for millstones)

Lancha: large slab of rock (natural formation)

Molar (piedra): silicieous millstone rocks

Molar (piedra): in the region of Palencia refers to conglomerates with small rounded clasts

Molinaza (*piedra*): fine, reddish sandstone (*Bundsandstein*)

Panalizo (piedra): rock that is soft when extracted but very hard when dry

Piedra basta: literally coarse stone; it probably refers to conglomerates or puddigstones with large clasts

Piedra de grano: In the Palencia mountains, this term refers to conglomerates or puddingstones with pebble inclusions (Basterra 2003: 249). In certain contexts corresponds to granite (presumably white biotite granite)

Sal y pez (piedra): designates a white and black biotite granite. (*Sal* (salt) is white and *pez* (tar, not fish) is black

Toba or "*tova*" (*piedra calcarea*): calcareous or limestone tufa

Toba volcánica: volcanic tuff

Tosca (piedra): porous limestone

Travertino: used to designate limestone tufa

Rock formations (terrain formation):

Berrueco, barrueco, berrocal: terms that designate granite landscapes. The are often made up of rounded boulders of different sizes sculpted by erosion. The term can refer to a small mountain to a vast region

Bolo, bola: rounded granite boulders of different sizes sculpted by erosion. Typicals of Berroqueño landscapes

Piedra caballera: pedestel rock, naturally sculpted boulder perched in equilibrium on a small base. This feature is known in berroqueño and limestone karstic landscapes

Canchal or *canchales* : accumulation of rocks, such as talus, usually with angular shapes

Lanchar: terrain with "lanchas" (slabs)

Peña - Peñasco: crag

Pedregal: terrain with loose rocks

Dwellings:

Covachas: hovel

Caracolas: hovel

Flour and bread:

Blanco: white

Harina: flour

Pan: bread

Prieto: dark

Moreno: dark

Bazo or *Baxo*: dark; at times interpreted as *bajo* meaning low, as in unleavened bread

Transport:

arriero: transporter of goods by mule

carretero: transporter of goods by cart

barquero: transporter of good by boat

*Corz*a: Y-shapped wooden "sled" dragged by animals used to transport millstones

Narria: simple sled

Carro: cart

Caballeria: equine (horse, mule, donkey)

Mula: mule

Buey: ox

Ownership, laws

Cabildo: ecclesiastic body that make up a ruling council; at times refers to the council

Consejo: council

Fuero: legal document or codice regulating the laws in land occupied after the Islamic domination

Apeo: legal document, related to the transfer of ownership of property

Pregón: ordinance transmitted orally

Annex 3
Extracts from the dictionaries of S. Miñano and P. Madoz

Extracts from the Miñano dictionary (1826-1829)

	Site	Year	Vol.	Page	Reference
M-4	Chapinería	1826	2	83	*"Produce granos y pastos, con buenas canteras de piedra barroqueña para molinos y edificios."*
J-1	Castillo de Locubín	1826	2	477	*"... Hay 3 canteras de jaspe, encarnado, negro, y de piedras á propósito para los molinos."*
GU-2	Pinilla de Jadraque	1827	7	24	*" Industria: extraer de su preciosa cantera piedras para molinos de otros pueblos, que son de escelente calidad."*
TO-2	Las Ventas con Peña Aguilera	1828	9	286	*"... adundan en colmenas y canteras de piedra berroqueña ó granito, con que surten de piedras de molino á mas de 30 leg. al rededor."*
CC-2	Villar de Plasencia	1828	9	43	*"... el piso es todo de canchales de piedra de silleria, de las cuales se sacan piedras de molino, que conducen á 4 y 6 leg. de dist."*

Extracts from the Madoz dictionary (1845-1850)

	Site	Year	Vol.	Page	Reference
GR-1	Moclín	1847	8	480	*"... y las de Moclin y Velez de Benaudalla escelentes piedras de molino."*
GR-2	Loja	1847	10	360	*"... las hay de panalizo blanco y rosado en el Cojin de Loja, para piedras de molinos harineros."*
GR-6	Fuente de los Morales	1847	8	216	*"Es notable por sacarse de su terreno las mejores muelas de molino para pan blanco, de que se surten hasta los pueblos de la prov. de Malaga"*
GR-10	Velez de Benaudalla	1847	8	480	*"... y las de Moclin y Velez de Benaudalla escelentes piedras de molino."*
GR-11	Caniles	1846	5	461	*"Al E., y dist. de 1 leg. de pueblo, hay una cantera de piedras de molino para pan moreno..."*
AL-8	Adra, Cerro el Chispa	1845	1	88	*"... Hácia el E. á dist. de 1/2 cuarto hora existe una cantera de piedras de molino."*
AL-9	Vera	1850	15	670	*"... contiene canteras de yeso y para baldosas y de ruedas de molino."*
J-1	Catillo de Locubín	1845	1	382	*"A la falda del O. de la Acamuña hay una elevacion que se denomina las Canteras, pues de alli re sacan las piedras de molino."*
J-3	Huelma	1847	9	260	*"Hay 3 canteras de piedra, una de ellas en el punto llamado la* Cantera, *de la cual se sacan piedras para molino y otros usos..."*
J-5	Andújar, Los Morales	1845	2	305	*"Las canteras de granito, que solo se emplean en molinos de pan y de aceite, puede decirse que son innumerables; pero las que estan en uso son las del Pedroso y Morales."*
J-6	Andújar, El Pedroso	1845	2	305	*"Las canteras de granito, que solo se emplean en molinos de pan y de aceite, puede decirse que son innumerables; pero las que estan en uso son las del Pedroso y Morales."*
J-7	Linares district	1847	10	290	*"... adundan las canteras de arenisca, escelente para la construccion; de granito para molinos harineros y de aceite ..."*
CO-9	Los Arenales	1849	15	136	*"... y en el sitio que llaman los Arenales una cantera para piedras de molino."*
CO-10	El Albardado	1846	4	131	*"En el arroyo Albardado se encuentra una cantera de pierra basta de molino, de donde se proveen los pueblos inmediatos y aun algunos mas distantes ..."*
CO-10	El Albardado	1847	9	39	*"... y por la izq. á otro 1/4 de leg. de dist. el Albardado, notable por las diferentes canteras para piedras de molino que hay á sus inmediaciones ..."*
CO-16	Minas de Espiel district	1849	14	382	*"Corre hácia el SO., y se compone de capas de piedra arenisca, mas ó menos basta, que principalmente suele usarse para construir piedras de molino ..."*

Code	Site	Year	Vol.	Page	Reference
CO-17	Fuente Obe-juna	1847	8	230	*“... á las inmediaciones del mismo camino y orillas de los r. Guadiato y Suja, se encuentran 2 abundantes canteras muy útiles para piedras de molino y tahonas ...”*
MA-2	Teba	1949	14	752	*“ ... estraccion de piedras de molino para molinos de agua y tahonas, que sacan de 10 canteras de jaspe blanco y encarnado, ...”*
MA-3	Alhaurín el Grande	1845	1	604	*“ ... viéndose igualemente al S. del pueblo otras varias canteras de granito, propria para ruedas de molino, pilones, umbrales ...”*
MA-5	Guaro	1847	9	56	*“... comprende un monte llamado del Señor, poblado de encinas, alcornoques y matas bajas, y una cantera apropósito para piedras de molino harinero.”*
MA-6	Alozaina	1845	2	186	*“En el de Alozayna se encuentran canteras para piedras de molino de mérito particular, ...”*
CA-8	El Berrueco	1846	4	290	*“BERRUECO (EL): monte en la prov. de Cádiz, part. jud. y térm. jurisd. de Medina-Sidonia... La piedra de que está compuesto es blanquísima y dura, famosa en toda la prov. , por sacarse de ella las mejores muelas de molino: hay 5 pedreras en las que se ocupan 23 hombres, que viven alli mismo, con privilegio de uso de armas, no solo por la obligacion que tienen de trabajar graciosamente en allanar algunas eminencias de piedra en Medina, sino porque persiguen á los rateros que aparecen á veces por aquellos cotornos. Sacan el año que mas, 64 piedras para molinos de agua ó viento, y 480 granos ó sean piedras para moler en las tahonas, redondeándolas y poniéndolas en estado de servir para el objeto: de los desperdicios sacan la mejor cal...*
CA-8	El Berrueco	1846	5	140	*“Piedras de amolar y de molino: las primeras se labran en Ubrique ... las segundas en el cerro del Berrueco de Medina.*
CA-8	El Berrueco	1848	11	343	*“En Medina hay fáb. de alfarería; otra de tejidos de lienzo; otra de piedras de molinos en el Berrueco.”*
CA-10	Peña Har-pada	1845	1	376	*“... hay una cantera de piedra para ruedas de molinos harineros en* Peña-Jarpa, *...”*
SE-3	Lora de Estepa	1847	7	690	*“... en la sierra existen tres canteras, una de jaspe aceitoso y dos de cipia; en la nombrada el Hacho otra de piedra bravia, blanca y apropósito para molinos de harina ...”*

	Site	Year	Vol.	Page	Reference
SE-5	Alanís	1845	1	190	*"... una cantera de piedra azul, á una leg. al SE., escelente para afilar las navajas de afeitar, y otras de piedras para molinos ..."*
SE-6	Villanueva de San Juan	1850	16	207	*"... y una cantera de molino que no se beneficia por falta de caminos."*
SE-7	Gerena	1847	8	348	*"... muchas canteras de piedra que se emplea bastante para los molinos de aceite."*
HU-6	Zalamea la Real	1850	16	450	*"El TERRENO es casi todo de sierra y secano... Encuéntranse diferentes canteras para piedras de molinos."*
CR-3	Chillón	1847	7	327	*"... en él se encuentra 2 canteras, una de piedra de granito para molinos ..."*
GU-6	Corduente	1847	7	9	*"... hay canteras de buenas piedras de molino ..."*
GU-7	Castilnuevo	1847	6	172	*"... varias canteras de piedra tova, de las cuales se surten los molinos harineros de la circunferencia."*
AB-1	Fuentealbilla	1845	1	51	*"... IND.: la agricultura, ganadería, fáb. de alpargatas, laboreo de piedras de molino que se estraen del sitio llamado el Molar, en el térm. de Fuentealbilla ..."*
AB-1	Fuentealbilla	1845	1	256	*"... y en le Molar, térm. de Fuente-albilla, del mismo part., la de piedras de molínos, de grano poco compacto, por lo que se aprecia menos que la barcelonesa."*
BA-4	Salvaleón	1849	13	711	*"Hay otros riscos mas pequeños; dos canteras de piedra de grano; una de piedra blanca para las ruedas de molino ..."*
BA-5	Jerez de los Caballeros	1847	9	627	*"... hay tambien canteras de piedras morena y blanca para molinos harineros ..."*
CC-4	Bohonal de Ibor	1846	4	376	*"El TERRENO participa de monte y llano, bastante quebrado, y con muchos berrocales y canteras de piedra muy dura, de donde se estraen buenas ruedas de molino ..."*
CC-6	Logrosan	1847	10	355	*"Al S. de la cab. del part. hay otra sierra bastante elevada, llamada de San Cristobal; ... hay en ella canteras de piedra de grano y se estraen muchas de molino y de lagar ..."*
M-2	Colmenar de Oreja	1847	6	525	*"... á la parte del N. se ven canteras de piedra blanca llamada de Colmenar, de donde se estrajo la que se necesitó par los palacios de Madrid y Aranjuez y otros muchos edificios; en el dia hay poca extraccion, estando limitada á algun baño y piedra para las tahonas de Madrid."*
M-3	Comenar Viejo	1847	6	530	*"... muchas canteras de piedra granito, de las que se sacan piedras para molinos harineros ..."*

Annex 4
Pinilla de Jadraque: Quarry to mill distances

List of 21 towns and hamlets and the number of flour mills in a radius of 20 km from the millstone quarry of Pinilla de Jadraque (GU-2). The quarry, according to Miñano had "excellent millstones ... extracted from its precious quarry for other towns" (Miñano 1827, Vol. 7: 24). The list suggest that the mills in the radius of 20 km would not have furnished enough volume of work for the quarry. It must have exported farther away.

Town	Distance from quarry (km)	Flour mills	Bibliography
Pinilla de Jadraque	1	1	Madoz 1849, Vol. 13: 36
Pálmaces	4	1	Madoz 1849, Vol. 12: 610
Congostrina	4	0	Madoz 1847, Vol. 6: 564
Torremocha de Jadraque	5	0	Madoz 1849, Vol. 15: 94
La Toba	5	0	Madoz 1849, Vol. 14: 767
Medranda	6	2	Madoz 1848, Vol. 11: 350
San Andrés de Congosto	8	0	Madoz 1844, Vol. 2: 298
Zarzuela de Jadraque	8	0	Madoz 1850, Vol. 16: 663
Hiedelencina	9	0	Madoz 1847, Vol. 9: 143
Cendejas de Enmedio	9	0	Madoz 1847, Vol. 6: 307
La Bodera	11	1	Madoz 1846, Vol. 4: 371
Jadraque	13	2	Madoz 1847, Vol. 9: 492
Gascueña de Bornova	13	0	Madoz 1847, Vol. 8: 328
Matillas	15	1	Madoz 1848, Vol. 11: 312
Semillas	15	1	Madoz 1849, Vol. 14: 168
Riofrío del Llano	15	0	Madoz 1849, Vol. 13: 489
Baides	15	0	Madoz 1846, Vol. 3: 301
Bustares	15	1	Madoz 1846, Vol. 4: 677
Cogolludo	16	3	Madoz 1847, Vol. 6: 513
Espinosa de Henares	17	1	Madoz 1847, Vol. 7: 574
Villanueva de Argecilla	18	0	Madoz 1850, Vol. 16: 200

UNIVERSITÉ DE GRENOBLE

THÈSE

Pour obtenir le grade de

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dans l'École Doctorale Sciences de l'homme,
du Politique et du Territoire

Les carrières de meules du sud de la péninsule Ibérique, de la protohistoire à l'époque moderne

PART II

CATALOGUE

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Catalogue of millstone quarries in southern Spain

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MILLSTONES QUARRIES IN THE SOUTH OF THE IBERIAN PENINSULA: from Protohistory to Modern Times

CATALOGUE

The catalogue consists of a brief description of the each of the quern or millstone (or reputed) quarries identified in our study area. The number of pages for each entry varies according to the data available. The length of the entries of the sites surveyed in the field is, for obvious reasons, greater than the entries based exclusively on secondary sources.

The structure of the catalogue follows the present political boundaries of Spain beginning with Andalusia, the largest autonomous community. Andalusia is subdivided into its eight provinces: Granada (GR), Almería (AL), Jaén (J), Córdoba (CO), Málaga (MA), Cádiz (CA), Seville (SE) and Huelva (HU). This is followed by Murcia (MU), a small mono provincial community. Murcia is followed by the large Community of Castilla La Mancha with five provinces: Ciudad Real (CR), Albacete (AB), Toledo (TO), Cuenca (CU) and Guadalajara (GU); This is followed by the community of Valencia with its three provinces of Alicante (A), Valencia (V) and Castellón (CS); Extremadura with the provinces of Badajoz (BA) and Cáceres (CC); and finally the mono-provincial Community of Madrid (M).

The codes attributed to each site that appear throughout this work are on the upper left of each entry and are based on the official abbreviations of the provinces. The site "GR-1" is hence millstone quarry 1 of the Province of Granada (GR).

The name of the municipality where the millstone quarry is located appears at the top of each entry. The name of the site, often a place name from either the cadastre, geographical or geological map, is in *italics* below the municipality. There are a few cases in which the name stems from a different source, such as an explanatory panel or from a local oral tradition.

Some sites do not have a name because we possess no information beyond that of the municipality. Other sites missing precise information as to their locality, such as Mérida (BA-6), Fuente Obejuna (CO-17), Linares (J-7), are accompanied by the term "district". This indicates a reported production, probably in the form of a number of small quarries, in an area most likely covering more than one municipality.

Below the name of the site are the geographical coordinates and the altitude. The absence of coordinates indicates the cases where the precise location is not known.

When possible and when relevant, the entry is accompanied by topographical, cadastral (SEC) and geological maps (IGME), satellite or aerial photographs (SIGPAC, Google Earth or Google Maps). For example, there are certain sites that we have only been able to "approach" by means of Google Maps Street View.

A large section of the catalogue is dedicated to photographs either taken during a field survey or received from a local contact. Each entry usually begins with a general view of the region to illustrate the geographical setting. Photographs also are chosen to illustrate different types of extraction and fashioning techniques, as well as abandoned products.

A few sites such, as Punta Camarinal (CA-2a), Paloma Alta (CA-2b), Cerro Bellido (SE-4) and Posadas (CO-8), are not millstone quarries. These Roman construction quarries appear, nonetheless, in this work because their products, mostly column segments, are reported to have been recycled into millstones. Besides, the rock type and the extraction techniques are similar to that of millstone quarries. Other sites are dubious. The main product of Cobeta (GU-9), for example, was probably sharpening stones.

The descriptive fields

The following fields are those that have been retained for the descriptions of each quarry. So as to avoid an extremely rigid system that might create repetition, or in the instances where the information is missing or not relevant, the concepts are sometimes grouped under one heading. When the information is missing, the heading is eliminated.

Location: General geographical information.

Generalities: The field applies to general aspects of the site and replaces the field of **location** in cases where the whereabouts of the site is not identified.

Source: This field is a brief description of the source of information on the site, whether it be a written text, information from the internet or a personal communication.

Toponymy: Place names play a primordial role in the identification of millstone quarries and are mentioned in this field. The most common names associated with millstone quarries are the names deriving from the Latin *mola* (*molares*, *moles*, *mola, molar* ...) meaning millstone or *cantera* meaning quarry.

The quarry: General description of the type of site (true extractive, block extraction...), the dimensions, the state of conservation.

Techniques: This field briefly surveys the extraction technique, whether it be true extractive or block detachment, and possible tool marks.

Product(s) and quantification: This field describes the product or products of each site and, when possible, estimates its number.

Transport and distribution: This field indicates both the presence of nearby paths or roads, as well as the presence of rivers or seas that could have served for maritime transport.

Dwelling: This field indicates if there is physical evidence at the site, such as hovels or huts where the quarrymen could have resided.

Bread: This field is completed when there is a mention in an old text of the type of flour yielded from the millstones of the quarry.

Dating: This field is one of the more difficult to complete. Sites can be dated by means of an old text or record in an archive. At times, the typology of the product yields the date.

Rock type: The main source of this field is the data interpreted from the maps and explanatory booklets of the Geological Survey of Spain (*Instituto Geológico y Minero de España - IGME*). This source, often based on research dating from the 1970s and 1980s, reveals the general geological tendencies of the outcrops in the area and cannot to be taken as the exact petrographical definition of the rock exploited.

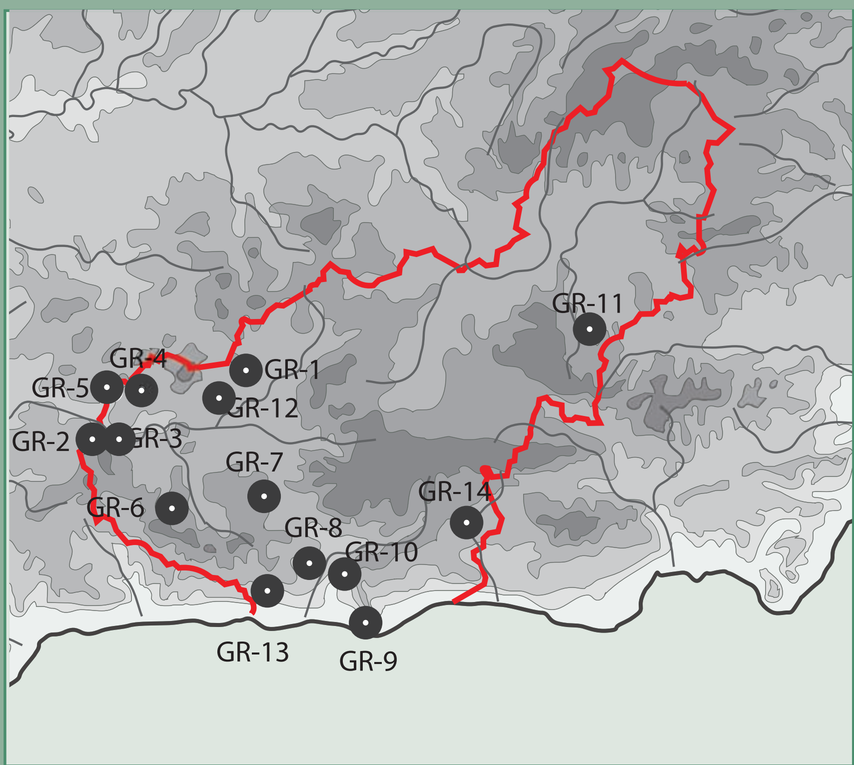
Each quarry entry is accompanied a by an extract of the geological map, and a few comments from the caption of the map of the explanatory booklet. In some cases, when the rock type indicated by the geological map does not correspond to that of the quarry, this information is ignored.

The IGME data is completed, in a few cases, with petrographical portraits undertaken by professional geologists (for example, from the University of Granada or the Norwegian Geological Survey). In these cases the authors of the analysis are cited. The petrography of the rock is also at times based on local geological case studies published in articles. The general geological data is also contrasted with the petrographical descriptions from old geographical or geological sources. The accuracy of many of these early descriptions, dating from a time when geology was still in its infancy, is surprising. Finally, this field is completed by our own observations.

To facilitate consultation, each entry of the catalogue with the information of the **source(s)** consulted (for the most part internet sites) and the traditional **bibliography**. The many people who acted as guides to the sites or provided information or photographs for the catalogue are recognise in the **acknowledgements**.

Finally, many entries of sites not identified in the field are incomplete or present, at best, scanty information. For example we often propose, based the examination of place names, potential locations of the sites. Although not confirmed in the field, they are nonetheless left in the catalogue and should be taken as hypotheses that require will require verification in future research.

ANDALUSIA
GRANADA (GR)

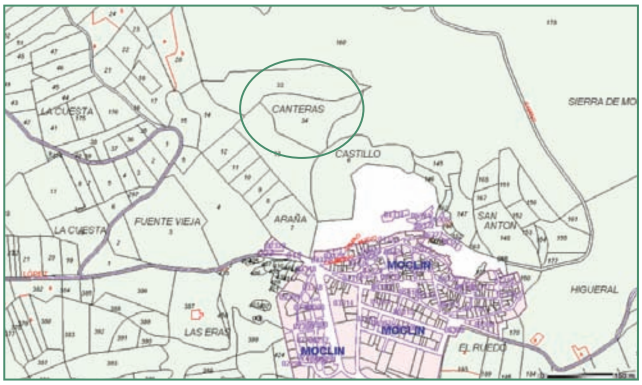


GR-1a Moclín

Canteras

Latitude: 37º 20’48,60”N
Longitude: 3º 47’ 14,10”W
Altitude: 1140 m

Location: The millstone quarry of Moclín is at the southern end of the Sierra del Marqués on a narrow promontory just a stone’s throw northwest of the town, under the Moorish castle.



Extract from the cadastre with the toponym Canteras (SEC).

Sources: In his general account of quarry work in the Province of Granada, the 19th-century geographer Pascual Madoz cites the “excellent millstones” from Moclín (Madoz 1847, Vol. 8: 480). A second author echoes the words of Madoz twenty years later in a general chronicle of the Province of Granada (de Dios 1869: 16). We have also noted the site in recent articles (e.g. Anderson & Scarrow 2011: 263).

Toponymy: The place name *Canteras* (quarries) on the cadastre coincides with the workings. The name *Los Agujerones* (large holes) to the north is possibly related to the numerous circular extraction hollows.

View of the Moclín site from the northwest.

View from the southwest of the Moclín millstone quarry. Working debris from the northern sector of the quarry is visible on the slope, to the left.

View of the southern sector of the quarry.

The quarry: From tip to tip, this site measures about 250 m in length and 20 to 25 m in width. It can be divided roughly into three main sectors.

As one enters the quarry from the town, the southern sector, detached from the rest, is to the right of the path with extractions on a large block that juts out under the Moorish Castle. This block comprises several vertical tubular extraction hollows along the edge of the ridge. Millstones larger than 1 m in diameter were scored here.

Along the path, between the southern and the central sectors, a portion of the site has been destroyed by a mechanical digger that has left scars of its teeth on the rock face.

The central sector comprises horizontal tiered extraction hollows and a few tubular hollows. Long vertical tubular hollows are absent because the sites is jumbled with "karstic" outcrops. This sector, unfortunately, is partly filled with modern waste.

The northern sector, the most spectacular area of the quarry is marked by a massive layer of homogeneous rock at least 5 m thick, permitting the mill makers to superimpose a series of circular extractions directly into the bedrock, resulting in a pit quarry with imposing vertical tubular faces covered with well-conserved diagonal pick marks. This part of the workings also has later defensive features (trenches, bunkers) dating, presumably, to the Spanish Civil War.

Well-conserved multiple diagonal lines, organised in groups with opposite orientation, mark the quarry faces. These tool marks are clear indicators of trenching with picks. The subsequent technique of splitting the cylinders from the bedrock is not visible because the quarry floor is either too weathered or covered with debris. We assume the workers employed metal wedges lodged in wedge holes to split the cylinders. One cylinder in a very advanced state of manufacture, perched high in the quarry, has been moved slightly with levers from its original extraction position and raised by slipping several small slabs below it. It is in this raised position, resting on rocks, that the cylinder was abandoned in the final stages of fashioning.

Extraction in the northern sector produced an immense volume of rock debris. A part of this white-coloured waste can clearly be seen strewn along the western slope of the promontory. The quarrymen were obliged to discard the debris outside the workshop to continue the progression downwards.

Products and quantification: The majority of the products visible are large millstones, certainly destined for watermills, and measure between 1,00 to 1,20 m in diameter. It is apparent that Moclín, in its later phases, produced hundreds of these large models. An aspect worth mentioning is that these products, although reputed as among the best in the province, required dressing on a daily basis (Reyes Mesa 2000: 49).

Besides the large extractions there are a few smaller examples measuring respectively abut 80 cm and 40 cm in diameter indication an early phase of exploitation of the site, possibly from Roman or Medieval times. These smaller roughouts, spread out through the central and northern sectors, are adjacent to areas of large, modern extractions. It is therefore plausible that more recent extractions erased the traces of older phases of work.

Transport, distribution and bread: Due to the steep slopes to each side of the site, the path leading from the edge of town is the only practical means of evacuating the millstones. Some large extractions, perched on high tiers of the quarry, must have been winched down the slope with ropes to join the path.

It is worth noting that the perforation of the eye is a feature that certainly helped to attach millstones during their transport. An elderly local resident, "Niño Ernesto", related that cylinders were rolled down the hill by several men by means of placing a wooden beam through the eye like an axle. This method is illustrated, in the study of the watermills of the Odiel River in the Province of Huelva (Gómez Ruíz 2003: 84).

As to commerce, the author of a study of mills in the Alpujarra region states that the white Moclín millstones were marketed as far as the south of the Province of Granada, a distance of about 60 to 80 km (Rodríguez Monteoliva 1989: 705).

Dwelling: The proximity of the quarry to the town, less than a few minutes walk, would have permitted the millstone makers to reside in town.

Dating: The different models extracted from this quarry suggests a long period of activity. "Niño Ernesto" recalls that the quarry was still active in the early part of the 20th century. The reference by Madoz pushes production back by about a century. Due to the size and number of large extractions at the site, it is safe to assume that production took place decades before the Madoz reference. The few smaller extractions measuring approximately 80 cm in diameter suggest a Medieval phase. Finally, the rotary hand-querns around 40 cm take the site back to at least Medieval times. A Roman exploitation would not seem probable due to the absence of querns of this rock type in from Roman contexts.

Rock type: Limestone and dolomite (Geological map, 991, Iznalloz, 1988). The stone is compact and homogeneous, an although its surface is greyish when weathered, freshly broken samples are bright white.

Views of the central sector of the quarry.

View from the south of the northern sector of the quarry. Working debris from the main workshop covers the slope.

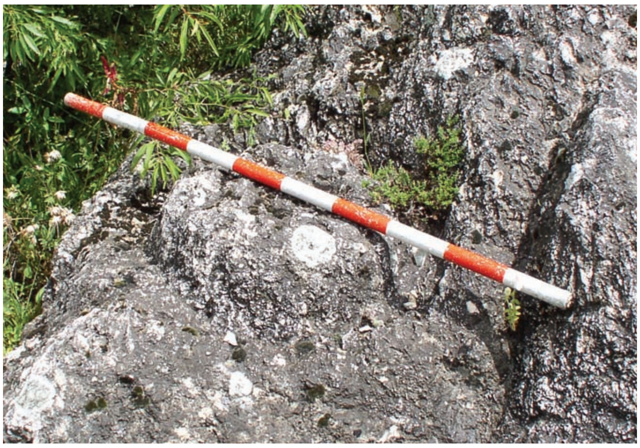
View from the northwest of the main quarry "pit" of the northern sector. The massive rock here allowed superimposed extractions resulting is in high quarry faces. The concrete construction is probably related to the defences dating from the Spanish Civil War. The Moorish ramparts can be seen to the left in the background, on the top of the hill.

View of one of the working faces of the northern sector of the quarry where millstones were extracted on superimposed levels leaving diagonal pick marks.

Detail of the northern sector of the millstone quarry with high quarry faces covered with diagonal pick marks.

View from the southeast of the northern sector of the quarry. The eye of the abandoned millstone is perforated.

Opposite page (top-bottom, left to right).: a-b) Details of unfinished rotary querns measuring 40 cm in diameter; c-d) details of medium-sized millstones and extraction hollow measuring approximately 80 cm in diameter; e-h) views of the larger millstone measuring between 1,00 and 1,20 m in diameter.

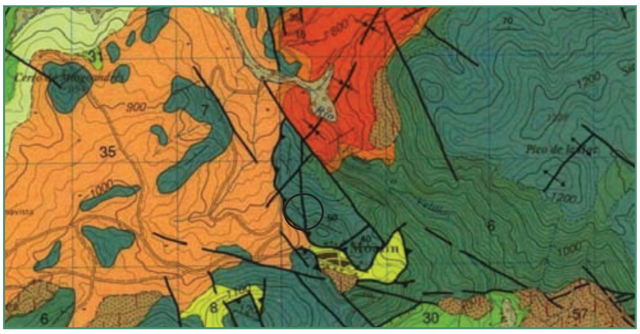







Examples of pierced millstones that decorate the public spaces of Moclín.

Detail of the working debris. The freshly broken rock is white, while the weathered surface is greyish.



Extract from geological map 991 (IGME). The quarry exploited a unit of hard limestone or dolomite (dark green).

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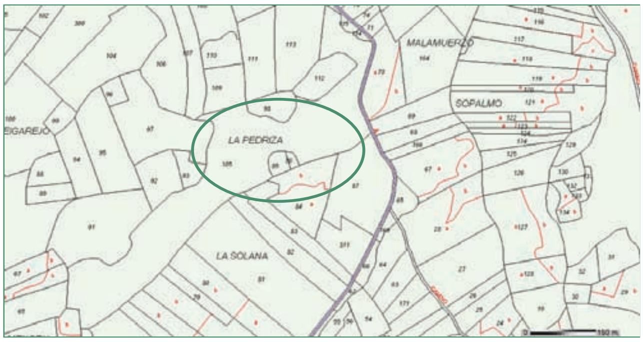
Gr-1b Moclín

Las Pedrizas

Latitude: 37° 20′ 59,49″ N
Longitude: 3° 47′ 50,98″ W
Altitude: 840 m

View from the south of Pedriza quarry. Millstones were scored from scree at the foot of the hill (Google Maps Street View).



Extract of the cadastre. The place name "La Pedriza" could be related to the millstone quarry (SEC).

Millstone extractions on boulders among the scree at the base of the Cerro de la Fresnedilla.

Location and Toponymy: This small millstone quarry is about 1,5 km northwest of the main quarry of Moclín, on the road about a third of the way to the hamlet of Tózar, at the foot of the Cerro de la Fresnedilla hill. The place name is *La Pedriza*, meaning a terrain covered with blocks.

The quarry: Instead of exploiting bedrock, the millstone makers focused their work on a series of detached boulders, some up to several metres large, in the talus at the base of the hill.

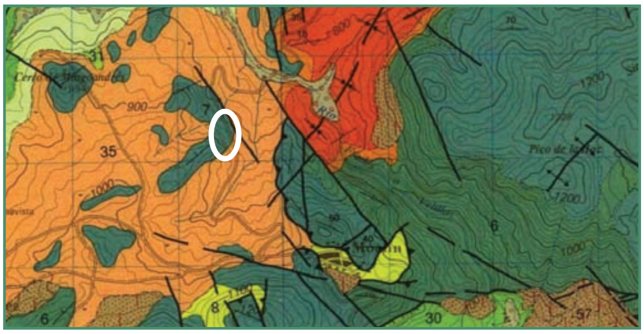
Techniques: Owing to the source of detached blocks, in order to follow the natural bedding plane of the rock, the mill makers had to work on vertical planes.

Transport and distribution: The quarry, next to the road between Moclín and Tózar, could have benefited from the distribution network of the large quarry of Moclín.

Products and quantification: The site is modest, comprising only about a dozen extraction hollows of millstones about 1,10 -1,20 m in diameter.

Dating: In this area, there is only evidence of the production of large millstones, placing the workings in recent times, contemporary to the later phases at Moclín (GR-1a).

Rock type: Limestone or dolomite (Geological map 991, Iznalloz, 1988). This rock bright white, identical to the rock exploited at Moclín.



Extract from geological map 991 (IGME). The quarry exploited a unit of hard limestone or dolomite (dark green).

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GR-2 Loja

Cerro de Fuensanta

Latitude: 37´10´21´28"N
Longitude: 4´10´25´20"W
Altitude: 520 m

View from the southeast of the low mound in the middle of the Loja Valley with the two sectors of the Cerro de la Fuensanta millstone quarry.

Location and sources: Loja is a town on the western fringe of the Province of Granada. It is on a natural passage way between eastern and western Andalusia. The written sources do not identify the precise location of the workings. The first source dates to 1502, ten years after the fall of Islamic rule. It is a *pregón,* a Municipal Ordinance delivered orally prohibiting the extraction of millstones without prior obtention from the authorities. The punishment for this deed was the confiscation of the millstones and a fine of 600 *maravedís* for the millstone maker and confiscation of the oxen from the transporter (Pregón 1502).

Madoz, several centuries later, records the existence of white or rose *panalizo* exploitations in Loja specifically for bread mills (Madoz 1847, Vol. 10: 360). *Panalizo* is an old Spanish term that designates a rock that is soft at the moment of extraction but grows extremely hard when dry (Ximénez de Guzmán 1756).

The quarries and techniques: Neither of the sites that we have identified in the surroundings of the city of Loja is very extensive. The first, the Cerro de la Fuensanta (GR-2), is two km west of the centre of the city. The second, Puente Quebrado, Camino del Calvario, is perched on a karstic slope just north of the city (see GR-3).

The workshops on the Cerro de la Fuensanta are found on the southern slope of a low mound located in the middle of the Loja valley. This small site is apparently subdivided into two areas separated by about 100 m.

The first, in the western sector, is a bench quarry located beside the path leading to the top of the mound and covers a surface of approximately 12 x 10 m. It consists of a series of circular, tiered extractions.

The millstones were hewn directly from the bedrock following the horizontal bedding planes. At least three different tiers are now visible, with the smallest, at the base in the central area, now overgrown with grass. Diagonal pick marks are visible on some of the extraction faces, showing that they were cut directly into the bedrock by means of trenches with picks.

The second extraction area is located on the same slope of the mound about 100 m to the east. This quarry is smaller, of the "karstic" type, and comprises a group of less than a half dozen extractions clustered in an area about 100 m^2, as well as a couple of isolated extractions elsewhere on slope. In spite of a weathered surface of the rock, it is possible to distinguish the typical trenching with a pick. One of the singular aspects of this quarry is that it is a rare case in which one can see the wedging method the quarrymen applied to split the cylinder from the bedrock. The holes destined for what were probably iron wedges are still visible on the surface. These regularly spaced holes are trapezoidal with their longest measurement at approximately 15 cm.

Products and quantification: Both sectors produced large millstones measuring about 1,30 m in diameter destined for watermills. In this western sector one smaller and thicker cylinder measuring 90 cm in diameter, might have been destined as a roller for olive oil production. Between the two sectors, about 100 millstones could have been produced.

Transport and distribution: The ordinance of 1502, with its reference to oxen, provides a clue to the method of transport. For the later productions, contemporary to the 19th-century geographer Madoz, we can imagine a similar type of transport. In any case, transporting the millstones from these quarries was certainly not a major task on account of the absence of natural obstacles. Distribution was probably local.

Dating: The ordinance places activity in millstone production from at least the time of the *Reconquista* of the city (1486). It is perfectly conceivable that this production continued at least until first half of the 19th century, as evidenced by the Madoz reference. In spite of Loja's rich tradition dating to prehistory, with flint quarries in the urban area, we have no evidence of millstone production pre-dating the Catholic reconquest.

Rock type: White limestone (Geological map 1008, Montefrío, 1985).

View from the west of the western sector of the Cerro de Fuensanta quarry. From left to right are visible the different tiers of millstone extraction.

The Ordinance of 1502

1502, enero, 10. Loja.

Pregón de la ordenanzas de Loja sobre no sacar piedras de molino.

(Cruz). En X de enero de IUDII años se pregonó lo sigente por aquerdo del alcalde mayor e Diego Rodrigues e el lyçençiado Morales.

Que ninguna persona sea osado de sacar pyedras de molyno de los terminos desa çibdad sin lyçençia del cabildo, so pena quel lo saqare que pyerda los bueyes con que los saqare; el maestro que lo hysiere que aya caydo en pena de DC maravedis e más las pyedras perdydas por sacar fuera de la çibdad.

Pregonose por Diego de Meryda, pregonero.
Testigos: el alcayde Inesta, e alcayde Herrera e otras mucha personas.

(AML, Leg. 49, p. 9. 1 cuartilla + 1;)

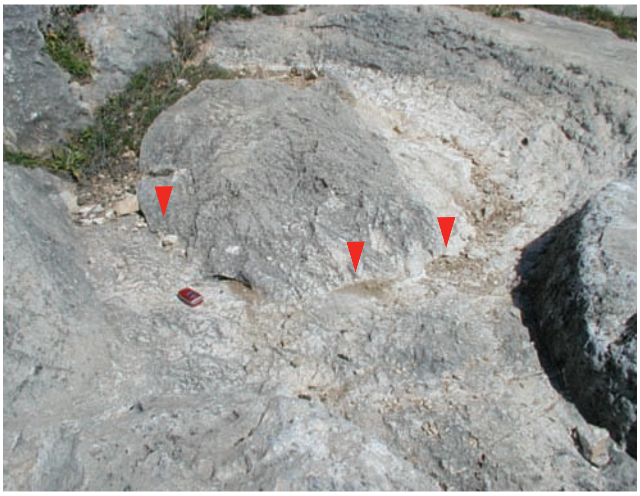
Details of extraction hollows with pick marks.

Detail of an extraction in the western sector. Pick marks on the extraction face are clearly visible.

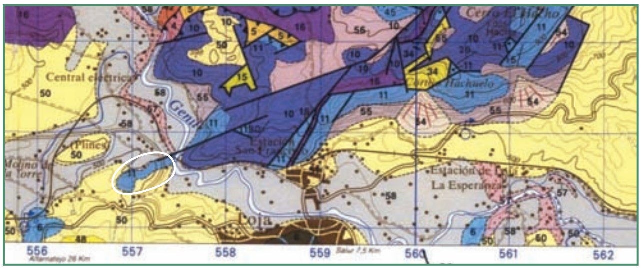
Detail of an extraction in the western sector. The smaller unfinished cylinder could be an oil roller.

View from the west of the cluster of extractions of the eastern sector of the Cerro de Fuensanta millstone quarry.

Detail of a "solitary" unfinished cylinder near the eastern sector of the quarry.



Details of wedge holes to split the cylinder from the bedrock.



Extract from geological map 1008 (IGME). The quarry exploited a white limestone unit (blue).

Source

Loja Ordinance: Pregón 1502, enero, 10. Loja, Pregón de la ordenanzas de Loja sobre no sacar piedras de molino. AML, Leg. 49, p. 9. 1 cuartilla + 1; http://www.teresadecastro.com/Fuentes/DocMunic/DOCLOJA.6.htm [accessed February 9, 2011].

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GR-3 Loja

Camino del Calvario

Latitude: 37 ' 10' 21' 28"N
Longitude: 4' 10 ' 25' 20"W
Altitude: 605 m

Location: The second is a quarry perched above the city of Loja on the rugged, karstic southern slope of the Puente Quebrado Mountain. The site is on both sides of the Camino del Calvario, a road that winds up the mountain. Modern work on this road has destroyed part of the site and displaced a few millstones.

Sources: See GR-2.

The quarry: The site is presumably an extensive dispersed exploitation. It is plausible that surface boulders were also exploited in this rugged landscape.

Techniques: The surface of the unfinished extractions are extremely weathered and do not show the original tool marks. It is probable that they were cut by pick and split with wedges.

Products and quantification: Large millstones measuring over 1 m in diameter were scored at this site.

Transport and distribution: If the modern road was founded on an older thoroughfare, this road will have served to transport the millstones downhill to the city.

Dating: From the size of the extractions, this quarry could well be one of the exploitations cited by Madoz for the early part of the 19th century.

Rock type: Limestone (Geological Map 1025, Montefrío, 1985). White and homogeneous.

View from the southwest of the location of the of the Camino del Calvario quarry.

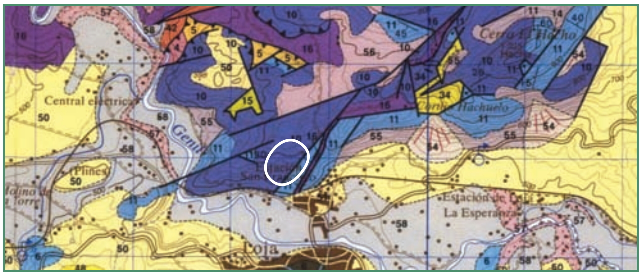
View of the karstic landscape of the slope with the position on an abandoned millstone.

Views of a solitary unfinished millstone.

Detail of the solitary extraction measuring 1,30 m in diameter.

View of an unfinished millstone.

View of material displaced during road work.



Extract from geological map 1008 (IGME). The quarry exploited a limestone unit (blue).

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ANDERSON, Timothy, SCARROW, Jane H. Millstone Quarries in Southern Spain: Preliminary Pinpointing of Provenance and Production - Exploiting the Internet. In: WILLIAMS, David, PEACOCK, David (eds.), *Bread for the People: The Archaeology of Mills and Milling, Proceedings of a Colloquium Held in the British School at Rome, 4th-7th November, 2009*, University of Southampton Series in Archaeology, no. 3, Archaepress, Oxford, 2011, p. 259-275.

GR-4a Loja

La Merced 1

Latitude: 37º 15′ 41.57″ N
Longitude: 4º 9′ 13.47 W
Altitude: 845 m

View from the north of the quern extractions along the bed of the ravine.

Detail of the cluster of quern extractions.

Location: La Merced 1 is the smallest of 3 quarries on the southwestern edge of the La Merced Mountain in the northern district of the Loja Municipality.

The quarry: This site, directly in the bed of a ravine, consist of only 3 surface extraction hollows cut into the same layer of rock exploited in the nearby subterranean millstone quarry La Merced 2 (60 m downhill, see GR-4b).

Products and quantification: The extractions correspond to rotary handmills measuring about 50 cm in diameter. This is the only "quarry" this far that could fall into the category of a "prospecting" site to test the quality of the stone (Grenne *et al*. 2008, 51).

Transport: The site is along the N-S road linking Loja to Algarinejo.

Dating: Based on the size of the extractions, the site dates to the Medieval period.

Rock type: Bioclastic calcareous sandstone (Geological map 1008, Montefrío, 1988; Cambeses 2011, unpublished).

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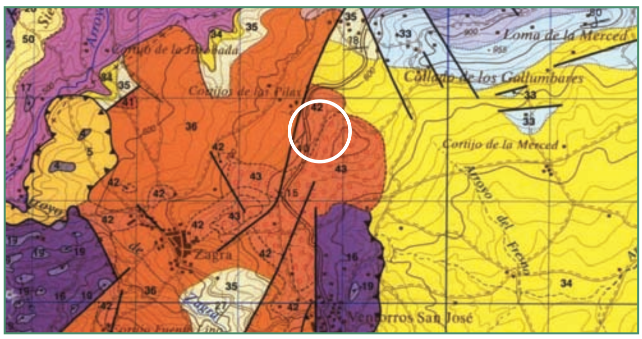
GRENNE, Tor, HELDAL, Tom, MEYER, Gurli B.,Bloxam, Elizabeth. From Hyllestad to Selbu: Norwegian millstone quarrying through 2000 years. In SLAGSTAD, T. (ed.) *Geology for Society, Geological Survey of Norway Special Publication*, 11, Trondheim, 2008, p. 47-66.

Acknowledgements

I thank Juan ORTÍZ, historian from Algarinejo, for leading me to the different sites of La Merced.



Extract from geological map 1008 (IGME). The quarry corresponds to a bioclastic calcareous sandstone unit (orange with circles).

GR-4b Loja

La Merced 2

Latitude: 37º 15′46,11″N
Longitude: 4º 9′10.68″W
Altitude: 835 m

View from the south of the subterranean millstone quarry of La Merced 2 (from Google Maps Street View).

Location: La Merced 2 is at the base of the mountain beside the road that links the towns of Ventoros de San José and Algarinejo.

The quarry: This is the only subterranean millstone quarry documented thus far in southern Spain, The cavern, in part destroyed by road work, is relatively small, measuring 9 m wide and 3,5 m deep. Its ceiling today, partially caved in, is about 2,5 m high.

Techniques: The quarrymen exploited a specific stratum of brownish massive sandstone directly beneath a brittle layer. On account of the thick overburden (more than 10 metres) superseding the stratum, it would have been impossible to attain this layer by any other means that than of tunnelling. Millstones were extracted directly into the bedrock by means of trenching leaving extraction hollows. Several tiers are visible. It is possible that the lower tiers, at the mouth of the workings, were destroyed during road work. Tool marks are not visible.

Products and quantification: In this quarry two different models of millstones were extracted. The first, more frequent, were small models measuring approximately 70 cm in diameter. The second corresponds to larger millstones about 1,10 to 1,20 m in diameter. This second production is presumably contemporary to the large extractions upslope (see La Merced 2, GR-4b).

Transport: The site is along the N-S road linking Loja to Algarinejo. The quarrymen would have benefitted from the road for transport.

Dating: The two models of cylinders point to two chronological phases. The smaller cylinders are probably Medieval while the larger models indicate a more recent, Modern or Contemporary, production.

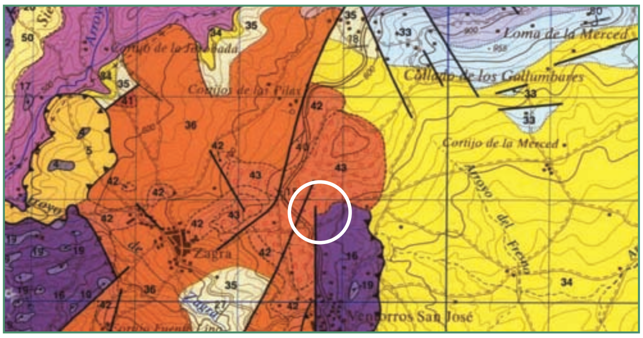
Rock type: Bioclastic calcareous sandstone (Geological map 1008, Montefrío, 1988; Cambeses 2011, unpublished).

View from of the mouth of the subterranean millstone quarry.

Views of the northern (left) and southern (right) halves of the quarry. The homogenous sandstone stratum exploited for millstones is below a brittle, unserviceable layer.

Detail of the extractions at the southern end of the quarry corresponding to small millstones approximately to 60-70 cm in diameter.

Detail of the extractions at the northern end of the quarry corresponding to small millstones approximately to 60-70 cm in diameter. The extraction under the ranging rod corresponds to a larger cylinder between 1,10 and 1,20 m in diameter.



Extract from geological map 1008 (IGME). The quarry corresponds to a bioclastic calcareous sandstone unit (orange with circles).p

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GR-4c Loja

La Merced 3

Latitude: 37º 15′ 44,36″ N
Longitude: 4º 9′ 19,31″ W
Altitude: 850 m

View from the southwest of the position of the large millstone extraction hollows.

View from the west of the seven contiguous millstone extraction hollows.

Location: The third millstone quarry around the Merced Mountain is an open-air exploitation that exploited a specific stratum of sandstone about 10 metres above the underground quarry in the sector (La Merced 2, GR-4b).

The quarry: This edge quarry presents an extended face about 15 metres in length comprising seven contiguous tubes of two to three superimposed, horizontal extractions. In this area, there is also a single hollow halfway between this edge quarry and the base of the hill.

Techniques: The rock surface is too weathered to observe any tool marks. These tube-like hollows are, nonetheless, typical of the technique of extracting cylinders from the bedrock with a pick.

Product and quantification: The size of the hollows corresponds to millstones about 1,10-1,20 m in diameter. The production here is estimated to be about 20.

Transport and distribution: The site is along the N-S road linking Loja to Algarinejo. he quarrymen would have benefitted from the road for transport.

Dating: The dating of this site is uncertain. Judging from the size of the extractions, it could range from Medieval to Contemporary times.

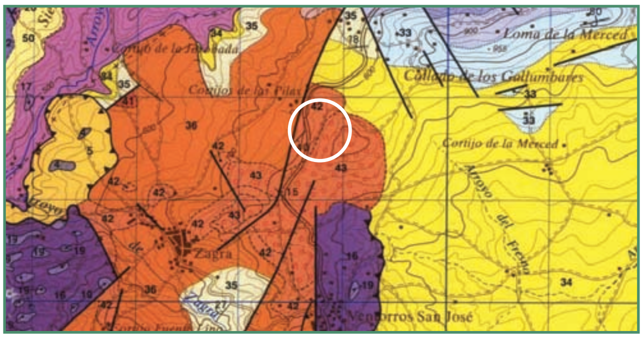
Rock type: Bioclastic calcareous sandstone (Geological map 1008, Montefrío, 1988; Cambeses 2011, unpublished).

Detail of the tube-shaped superimposed hollows.

Detail of the tube-shaped hollow.

View of a solitary extraction below the main cluster of tubular hollows.

Detail of an unfinished cylinder.



Extract from geological map 1008 (IGME). The quarry exploited a bioclastic calcareous sandstone unit (orange with circles).

Bibliography

CAMBESES, Aitor. Informe Petrográfico Sobre las Canteras de Molinos Cerca de Zagra, Granada, 2011, 4 p. Unpublished report.

GR-5 Zagra

La Atalayuela

Latitude: 37º 15' 44,97" N
Longitude: 4º 9' 49,08" W
Altitude: 740 m

View from the east of the promontory with the Atalayuela quern quarry.

View from the north of the northern sector of the rotary quern quarry. In the background is nearby promontory with ruins of a Medieval settlement.

Location and generalities: The rotary quern quarry of the Atalayuela is in the Municipality of Zagra, less that 1 km west of the La Merced workings (see: GR-4a-c). The site exploited a sandstone outcrop overlooking the valley of the Pesquera de Genil River and is unique in that it is not only the largest true extractive quern quarry to date in southern Spain, but the outcrop is shared with a small Medieval cemetery comprising a dozen rock-cut inhumation chambers.

Source: Our first knowledge with the site was through a video on the internet (Video Foro Montefrío). Millstone work is also cited in passing in a brief description of the Medieval cemetery (Jiménez Puertas 2002: 224).

The quarry: The site can be divided roughly into 4 sectors. The northern sector, a bench-type quarry, presents numerous horizontal circular small quern hollows, side by side and organised on several tiers.

The southern sector, also of the bench type, has small rotary quern extractions. The quarry face here comprises multiple superimposed extractions forming vertical "tubes" indicating at least 3 levels of extraction. The quarry floor in this sector is, for the most part, overgrown with vegetation.

The western sector corresponds to a large block about 4 x 4 m at the point of the promontory that juts out above the valley. Here there are two small clusters of the hand-quern hollows, as well as a single large unfinished cylinder (1,20 m in diameter) surrounded by a trench 25 to 30 cm wide. The motive for the abandonment of this cylinder, the only large millstone at the site, remains a mystery because the rock does not present any flaws.

The eastern sector of the site consists of a Medieval cemetery with 9 trapezoidal and rectangular chambers hewn directly into the rock dating roughly to the Visigothic period (6th - 7th centuries) (Jiménez Puertas 2002: 226). Most of the potsherds collected during a surface survey, however, date from to the 10th to the beginning of the 12th century (Jiménez Puertas 2002: 226), a period corresponding to Islamic rule.

Techniques: The severe weathering of the rock renders the observation of the tool marks difficult. We suppose that the circular trenches were cut by pick. As to the technique of splitting the cylinder from the bedrock, we can observe (with difficulty) a few cases of regularly spaced marks along the periphery of the cylinder. These could be marks of the chisel that provoked the splitting of the cylinder from the bedrock. The marks could also be traces of cavities destined to lodge small wedges or pegs.

Products and quantification: These extractions correspond to rotary handquerns measuring 50 cm in diameter. The only exception is the single large unfinished extraction (1,20 in diameter) in the western sector.

Transport and distribution: The quarry is above the valley of the Rio Pesquera de Genil, a tributary of the Genil River, 5 kilometres to the southwest, that flows through the natural thoroughfare linking the east to west of Central Andalusia. The large number of querns scored at the site suggests a production destined beyond the local sphere. The modern road linking Zagra to Alarinejo, probably based the route of an older thoroughfare, passes directly beside the site.

Dating: The size of the querns (50 cm in diameter), suggest a Medieval date. The chronological relationship with the nearby Medieval cemetery is not clear. It is difficult to conceive, nonetheless, that the cemetery, with its consecrated ground, and the rock workings, a mundane craft, were contemporary. There is, however, no visible contact between the tombs cuttings and the quern extractions to establish a relative chronology.

A study of the morphology of the funeral chambers suggests a 6th - 7th-century date for the cemetery, while the pottery collected on the surface (no proper excavation has been undertaken) falls into the 10th through the beginning of the 12th centuries (Jiménez 2002: 226). Since the pottery does not concord with the cemetery, it is plausible that it is related to the quarry. This would therefore place the quern production well into the Islamic domination.

The large isolated and unfinished extraction measuring 1,20 m in diameter is certainly later than the rest of the extractions and could date from the Late Medieval period to Contemporary times.

Rock type: Bioclastic calcareous sandstone (Geological map 1008, Montefrío, 1988; Cambeses 2011, unpublished).

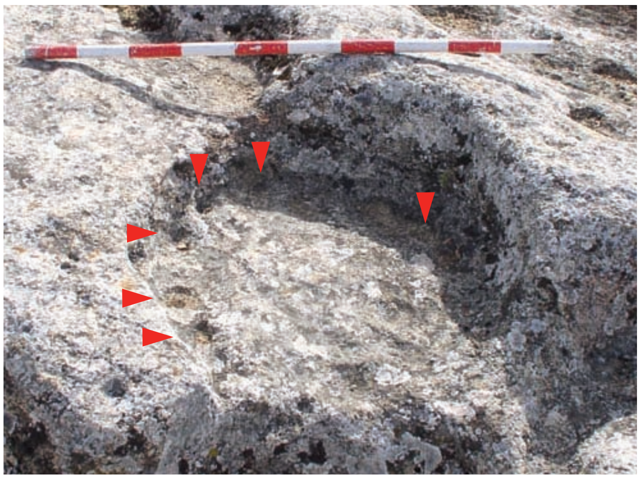
View from the southwest of the northern sector of the quarry.

Views of the rotary quern quarry's northern sector.

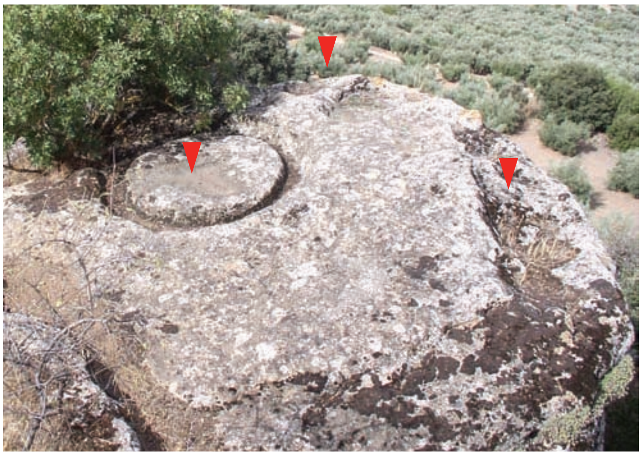
Views of the southern sector.

Views of the quarry face of the southern sector.

Details of rotary quern extraction hollows.



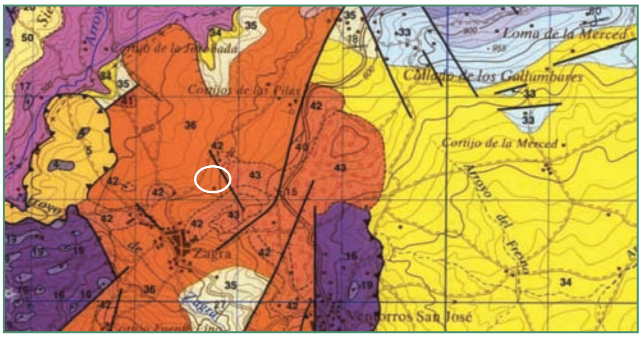
Detail of a rotary quern extraction hollow with poorly conserved splitting marks.



View of the quarry's western sector with a single large unfinished cylinder and two clusters of rotary quern extraction hollows.

Detail of a solitary unfinished millstone that is probably later than the quern extractions. Diameter 1,20 m.

Detail of a rock-cut tomb dating presumably to the 6th or 7th century. The cemetery with nine tombs is located in the site's eastern area.



Extract from geological map 1008 (IGME). The quarry is in a bioclastic limestone/sandstone unit (orange with circles).

Sources

Video Foro Montefrío: http://www.foromontefrio.com/index.php?topic=846.0 [accessed November 23, 2012]

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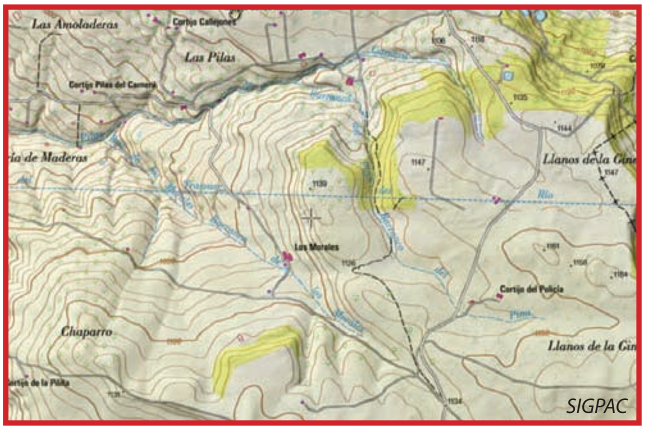
Acknowledgements

I sincerely thank Juan ORTÍZ, historian from Algarinejo, for leading me to the site.

GR-6 Alhama de Granada

Fuente de los Morales

Latitude: 36º 59' 59,73"N
Longitude: 3º 56' 44,67"W
Altitude: 1090 m



View of the Fuente de los Morales millstone quarry from the west.

Location, source and bread: The *Fuente de los Morales* is in the Sierra de Tejeda Mountains about 3 km east the city of Alhama de Granada. This exploitation is certainly one of the more important quarries of the western area of the Province of Granada, considering that the 19th-century geographer Madoz records that it produced excellent millstones that yielded flour for white bread.

Toponymy: The term *Morales*, meaning mulberry, could be a variation of *molares*, the toponym *par excellence* of millstone quarries. Another place name northwest of the site, *Las amoladeras*, related to *molares*, is normally linked with whetstone (*piedras de amolar*) workings. A third toponym, *Lomas de la Cantera,* meaning "hills or hillocks of the quarry" might evoke the large mounds of millstone working debris.

The quarry: The site is an edge quarry about 150 m long with a face several meters high. The quarry face is rough and bears no indication that cylinders were detached directly from the bedrock.

Techniques: The quarrymen apparently carved millstones from detached angular blocks. It appears the quarrymen followed a specific layer of hard, white limestone less than one metre thick. The large heaps of fine working debris at the foot of the outcrop, visible from afar, are probably the result of millstone fashioning adjacent to the quarry face.

Production and quantification: Several abandoned cylinders in the area range from 1,10 to 1,20 m in diameter. A semi-circular cylinder suggests the production of both monoliths and segments meant to be assembled by means of metal belts tightly fitted around their girth. Among the debris is a denticulated, trunco-conical roller. We ignore to what industry this roller was destined.

The length (150 m) of the quarry and the volume of the working debris mounds suggest a vast production. The possible manufacture of millstone segments would have certainly significantly increased the volume of production.

Transport and distribution: 1,5 km north of the site, there is an old road leading to the city of Alhama de Granada called "*Camino de las Amoladoras*" that could have been used to transport the millstones. A second option is the current road linking the site to Alhama. This second option is reinforced by the find of an abandoned millstone about half-way between the quarry and Alhama de Granada.

Madoz indicates that these millstones were commercialized all over the area, even to towns in the Province of Málaga, i.e. about 20-30 km km to the southwest, on the other side of the Málaga mountains (Madoz 1847, Vol. 8: 216).

Dating: There is no evidence of any exploitation earlier than the Contemporary date indicated by the Madoz reference.

Rock type: Limestones/breccia limestone (Geological map 1025, Loja, 1985; 1040 Zafarraja, 1978). The rock is a hard white limestone.

View of the northern quarry face.

View of the southern quarry face.

View of the mounds of working debris.

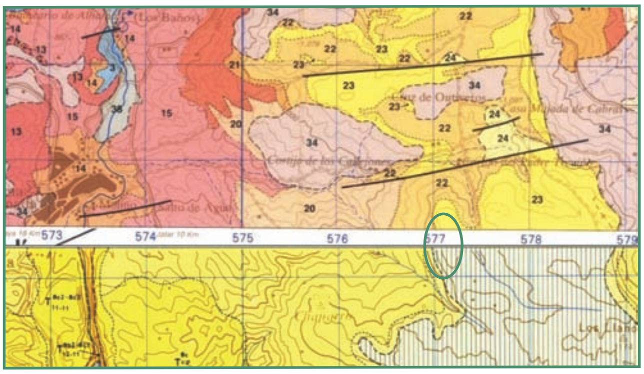
View of an abandoned millstone below heaps of working debris.

Abandoned millstones among the working debris.

Detail of an abandoned millstone segment.

An abandoned millstone measuring 1,10-1,20 m in diameter abandoned on the road between Alhama de Granada and the millstone quarry.

An abandoned denticulated trunco-conical roller.



Extracts from the geological maps 1025 and 1040 (IGME). The quarry exploited a limestone or limestone breccia unit.

Aerial view of the quarry. The working debris is plainly visible (SIGPAC).

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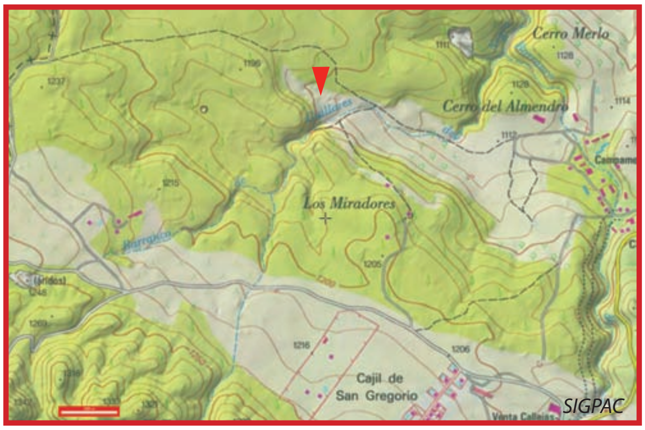
ANDERSON, Timothy, SCARROW, Jane H. Millstone Quarries in Southern Spain: Preliminary Pinpointing of Provenance and Production - Exploiting the Internet. In: WILLIAMS, David, PEACOCK, David (eds.), *Bread for the People: The Archaeology of Mills and Milling, Proceedings of a Colloquium Held in the British School at Rome, 4th-7th November, 2009*, University of Southampton Series in Archaeology, no. 3, Archaeopress, Oxford, 2011, p. 259-275.

MADOZ, Pascual. *Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultrama,* Madrid. 1947, Vol. 8: 216.

GR-7 Padul

Barranco de los Guillares

Latitude: 36º 59’ 43,00”N
Longitude: 3º 44’ 30,66”W
Altitude: 1160 -1170 m



View of the quarry from the northeast. In the centre, behind the vegetation, is the ravine with a great number of extraction hollows. The quarry continues to each side.

Location: The *Barranco de los Guillares* millstone quarry is along a ravine near the hamlet of Ventas del Fraile, about 15 km east of the town of Padul (Anderson & Scarrow 2011: 264).

Source: The quarry is identified by a web site related to the historical heritage of the Padul Municipality The web site is accompanied by many photographs. With its monumental size and imposing extractions, the absence of any old written document is surprising.

The quarry: The site is basically a T-shaped edge quarry exploiting both faces of the ravine along a NE axis before opening up laterally at the mouth of the ravine along the NW and SE faces.

Techniques: Along with Moclín (GR-1a) and the Cantera de Los Frailes (CO-1), this is an excellent example of superimposed horizontal extractions, like stacks of coins, producing tube-shaped quarry faces. The millstone makers cut large, deep trenches around the cylinders leaving numerous parallel diagonal pick marks clearly visible today on the extraction faces. The means of splitting the cylinder from the bedrock cannot be observed. In one area of the quarry, to the north beyond the mouth of the ravine, there is a group of extractions following vertical planes, indicating that the rock in this sector of the quarry was sufficiently homogenous to permit extraction opposite to the natural bedding plane of the rock.

Products and quantification: Only large cylinders (between 1,00 and 1,30 m in diameter) were produced at the site. These dimensions of quarry suggest the site hundreds of millstones were scored.

Transport and distribution: The quarry is located near the Camino de la Cabra, an old thoroughfare linking Granada and its plain with the Mediterranean coast at the level of the city of Almuñecar. Products from the quarry could access this road 2 km downhill to the east.

These millstones were certainly widely distributed in the region. The Valle de Lecrín, a nearby fertile valley with a mild micro climate, was know to have had many flour mills.

Dating: The absence of written sources complicates the dating of this site. A Roman date, suggested by the website, can be excluded based on the size and morphology of the millstones. The site can range from Late Medieval to Contemporary times.

Rock type: Bioclastic calcarenite or limestone (Geological map 1041, Dúrcal, 1978). The petrography is confirmed by the geologist Joaquín Sánchez, a millstone specialist from Menorca.

Orthophoto of the quarry to the left and the road leading to the east from the base of the quarry.

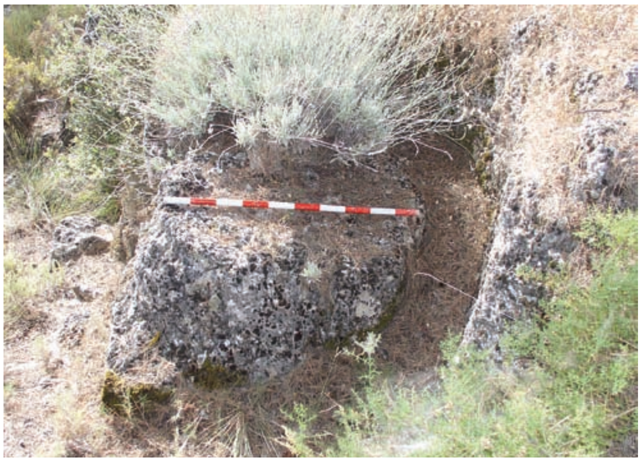
Detail of a series of tubular extraction hollows along the southern face of the ravine.

View of the extractions on the northern face of the ravine.

Views of tubular extraction hollows in different sectors of the quarry. Pick marks are well visible in the bottom right view.

Views of abandoned cylinders varying in diameter from 1,10 to 1,30 m.

View of the quarry's western sector.

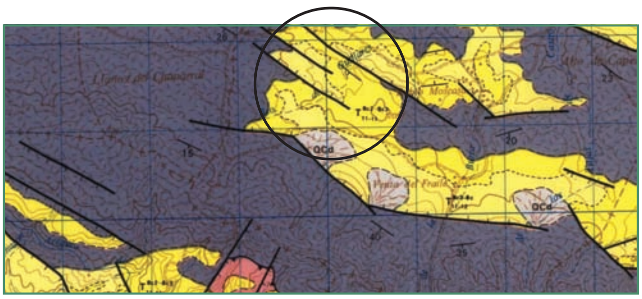


Detail of an abandoned horizontal cylinder in the western sector.

Detail of vertical extractions in the western sector.

Detail of an abandoned vertical cylinder in the western sector.

Detail of the rock type.



Extract from geological map 1041 (IGME). The quarry exploited a unit of bioclastic limestone (yellow)..

Sources

Padul Municipal web site: Cantera de Piedras de Molino: http://www.adurcal.com/enlaces/cultura/zona/historia/padul/cantemolin/index.htm [accessed November 7, 2012].

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GR-8 Los Guájares

Los Mochos, Guájar Faragüit

Latitude: 36º 50' 39,96" N
Longitude: 3º 35' 6,09' W
Altitude: 350 m

View from the north of a group of extraction hollows.

Location: The site is in the rugged Guájares mountains on the slope of the Rio de la Toba Valley. It is less than a kilometre north of the town of Guájar Faragüit, beside the *Finca* Los Mochos, a country house among the fruit plantations.

Source: The web site of the town of Guájar Faragüit, no longer available on the internet, mentions an ancient millstone quarry along a hiking itinerary.

The quarry: The site is very small and has only two levels of extraction. Its southern sector, beside the house, it is overgrown and filled with water.

Techniques: Parallel diagonal lines on the face of one of the extraction hollows indicated that millstones were cut out of the bedrock with a pick following the horizontal bedding plane of the rock.

Product and quantification: The quarry comprises less than a dozen circular hollows that measure approximately 1,60 m in diameter, corresponding to finished millstones between 1,10 and 1,20 m.

Transport and distribution: The few extractions were probably destined to local watermills along the narrow valley.

Dating: The size of the extraction suggests a date from Late Medieval to Modern times.

Rock type: Conglomerate (Geological map 1075, Dúrcal,1978).

Details of millstone extraction hollows measuring approximately 1,10 to 1,20 m in diameter

Extract from geological map 1075 (IGME). The quarry exploited a conglomerate unit (orange).

Sources

Los Guájares Municipal website "Ruta Avices, Pie Moro y Minchal" http://www.losguajares.es/turismorural.html [accessed in 2008, no longer available].

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GR-9 Motril

Playa de Carchuna

Latitude: 36º 41′41.30″″N
Longitude: 3º 26′17.42″W′
Altitude: 0-1 m

View from the west of the coastal millstone quarry of Carchuna.

Location and generalities: The quern and millstone quarry of Calahonda is located on the coast at the Playa de Carchuna, about 200 m west of the Fort of Carchuna. This fort, dating to the 18th century, was erected to protect the coastal area from marauding pirates. It is also known as the scene of a daring rescue of Republican prisoners in 1938 during the Spanish Civil War.

Source: Our knowledge of the quarry is a personal communication from I. Toro, director of the archaeological Museum of Granada.

The quarry: The site is a small surface quarry (only one level of extraction) that comprises about 20 large circular cavities spread along the coastline measuring about 50 m long. As one of the older local residents of the area noted, there the rocks have hollows "scooped out like balls of ice cream". It is reasonable to assume that some inland sectors of the quarry are now covered by sand and gravel that is periodically backfilled to maintain the beach.

Techniques: Owing to the alteration of its surface by the constant pounding of waves, it is not possible to make out tool marks. It is, nonetheless, safe to assume that the cylinders were cut with picks. In several large cases the trenches are up to 40 cm wide.

Products and quantification: The extraction hollows are for the most part between 1,80 and 2,00 m in diameter corresponding to millstones approximately 1,50 m. In one area, adjacent to the several large extractions, there are three contiguous small rotary quern extractions measuring 40 cm in diameter.

Transport and distribution: The sea could have facilitated transport by boat. Since the production appears to be small, we cannot conceive that these millstones travelled beyond a local sphere.

Dating: We have not identified any old texts that record the site. The smaller quern extractions suggest an early date (Medieval?). The large extractions, among the largest known in the south of Spain, fall into a date ranging from the Late Medieval to Contemporary times.

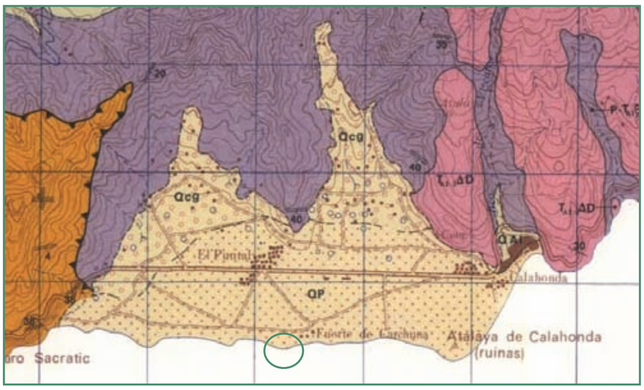
Rock type: Conglomerate (Geological map 1056, Albuñol, 1972). The clasts are rounded and measure up to 7-8 cm.

Large millstone extractions corresponding to millstones approximately 1,50 m in diameter.

Large millstone extractions corresponding to millstones approximately 1,50 m in diameter.

Three contiguous extractions corresponding to small hand-querns measuring 40 cm in diameter.

Detail of a rotary quern extraction hollow (40 cm in diameter).



Extract from geological map 1056 (IGME). The conglomerate quarry layer is too restricted to appear on the map along the coast (beige with dots represents beach sands). Conglomerates, however, do appear inland (beige with circles).

Acknowledgments

I thank Isidro TORO, director of the Archaeological Museum of Granada, for knowledge of the site and Antonio QUESADA for details of its exact location.

GR-10 Vélez de Benaudalla

Barranco de las Piedras

Latitude: 36º 50'42,27''N
Longitude: 3º 30'8,44''W
Altitude: 340-350 m

View of the millstone quarry from the west.

Location: The quarry of *The Barrranco de las Piedras* is 15 km from the Mediterranean coast in the rugged slope above the Valley of the Guadalfeo River, about 1,5 km north of Vélez Benaudalla. Vélez Benaudalla is known traditionally for its numerous natural springs and watermills.

Source: In his description of the millstone quarries of the Province of Granada, Madoz mentions Vélez Benaudalla, along with Moclín (GR-1) and Loja (GR-2), as the more important producers (Madoz 1847, Vol. 8: 490; Madoz 1847, Vol. 10: 464; Madoz 1848, Vol. 11: 637). De la Rada, in his general chronicle of the Province of Granada twenty years later, echoes the words of Madoz (de la Rada 1869: 16).

Toponymy: The toponym *Barranco de las Piedras*, meaning "ravine of the stones" most likely is related to the ancient millstone production.

The quarry: The site is a mixture of an edge and talus quarry with extractions cut into rock toward the top of the slope and surface blocks exploited at its base. The site is about 100 m long. Working debris ranging from large blocks to fine knapped flakes and abandoned millstone drums are strewn about the area.

Techniques: Parallel diagonal lines on the quarry face indicate the use of picks to cut the circular channels around the future millstones. Due to the high number of natural fissures, the millstone makers applied different techniques. Some blocks were pried while others were cut in true extractive fashion. Most of the extractions, as usual, followed the natural horizontal bedding plane of the rock. One attempt at a vertical extraction on a displaced boulder was aborted.

Products and quantification: The abandoned cylinders measure between 1,20 and 1,30 m in diameter. It is difficult to estimate the number of extractions. Based on the size and present shape of the outcrop, it would have been possible to remove several hundred cylinders.

Transport and distribution: The Madoz reference suggests that the quarry benefited from a wide distribution. In any case, the stones could have travelled up and down the Guadalfeo River Valley without any major obstacles.

Dating: The reference of the geographer Madoz, places this site in the first half of the 19th century. There is no evidence of earlier production.

Rock type: Dolomites and limestones (Geological map 1042, Lanjarón, 1978).

View of the quarry from the south. The Guadalfeo River Valley is seen in the background.

View from the summit (east) of the quarry. Three abandoned millstone extractions are seen on different tiers of the quarry.

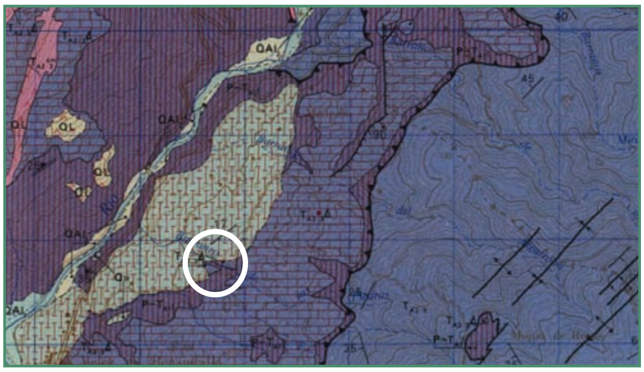
Detail of an abandoned millstone.

Detail of contiguous extraction hollows with faces bearing diagonal pick marks.

Detail of an abandoned millstone extraction. The trench cut to the right of the cylinder is between 25 and 30 cm wide.

Abandoned millstone in an advanced state of manufacture. The eye is pierced.

Abandoned millstones a few hundred meters away from the quarry along a road.



Extract from geological map 1042 (IGME). The quarry is located in a unit of dolomites and limestones.

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Ibid, Vol. 10. 1847.

Ibid, Vol. 11. 1848.

GR-11 Caniles

Rambla de las Canteras

Latitude: 37”29¨´21.18” N
Longitude: 2”37´45.20” W
Altitude: 930 m

Aerial view of the trench quarry of Rambla de las Canteras (Orthophoto, SIGPAC).

Location: The millstone quarry of Caniles is 9 km northeast of the city of Caniles along a dry riverbed called the *Rambla de las Canteras.* This riverbed winds roughly from east to west through the flatlands of the Hoya de Baza.

Source: 19th-century geographer Madoz (1846, Vol. 5: 461) identifies this quarry.

Toponymy: The word *cantera* (quarry) appears both in the name of the site (*Rambla de las Canteras,* meaning “dry riverbed of the quarries”) and in the name of the nearby farm (*Cortijo de las Canteras*). Although unaware of the presence of a millstone quarry, Pedro Rodríguez Sánchez, a resident of the nearby hamlet of El Francés, informed us that the name of the area where production took place is commonly known as *Piedras de Molino* (millstones).

The quarry: The surface corresponds to approximately 4000 m2. A layer about 1 m thick of conglomerate, exposed along the edge of the dry riverbed, was exploited in trenches. The quarrymen presumably pried out rough blocks with levers from the conglomerate layer, a technique that left no traces on the quarry face, before fashioning them into millstones.

The principal features of the site are the long, parallel cordons of working debris 4 to 5 m wide and up to two metres high between the two long trenches. The large quantity of debris is the spoil resulting from the fashioning process.

Products and quantification: We have identified only one abandoned cylinder measuring about 1 m in diameter and 40 cm thick showing traces of having one of its sides fashioned. It is difficult to quantify the production of this site. From the height and length of the waste cordons, we can imagine that the total number was in the hundreds.

Transport and distribution: The site is easily accessible and there are no natural obstacles to transporting the millstones to the nearly regions. The vast production would have favoured regional demands.

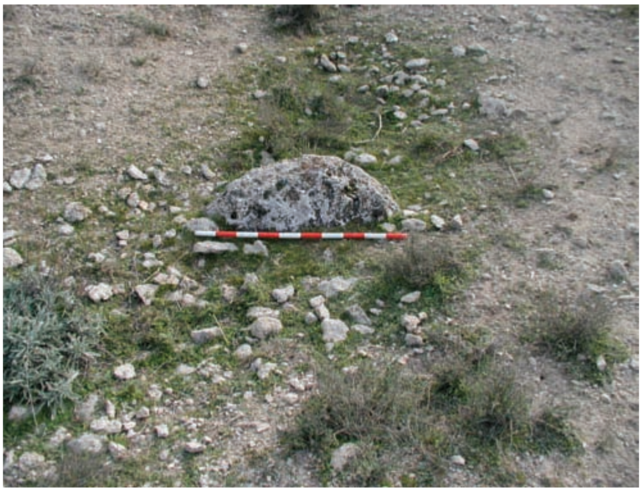
Bread: It is noteworthy that Madoz specifies that this quarry produced millstones for *pan moreno* (dark bread) (Madoz 1846, Vol. 5: 461). We can therefore assume that this type of rock (conglomerate) yields a type of flour that retains the bran. We can therefore speculate that the millstones from other conglomerate quarries also yielded dark flour. This detail relates to the preoccupation of the 19th-century society with the colour of bread.

Dating: The Madoz reference indicates that the site was exploited in the first half of the 19th century. In view of the quarry's size, work appears to have lasted many years.

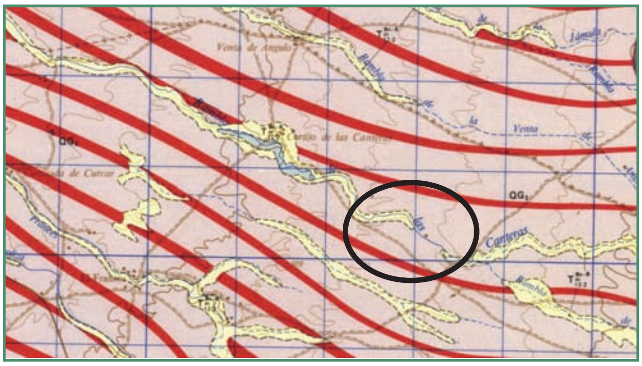
Rock type: The rock is a conglomerate with pebble inclusions up to 2 cm in a calcite matrix. Report by Juan Soto (Geology Department, University of Granada). The geological map (IGME 994, Baza 1978) does not present conglomerate at this location. It is probably a very local facies.

View of one of the conglomerate outcrops. The stratum is approximately 1 m thick.

Different views of the cordons of working debris of the Canitles trench quarry.



Views of a millstone about 1,00 m in diameter in vertical (working?) position between two debris heaps. In the photograph on the right, one can discern that one-half (on the right) was being fashioned before it was abandoned.



Extract from geological map 994 (IGME). The conglomerate exploited does not conform to the yellow unit of loams and limestones on the map.

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Acknowledgements

I would like to thank Juan SOTO of the Geology Department of the University of Granada for his description of the rock.

GR-12 Pinos Puente

Cantera de Zujaira

Latitude: 37º 15' 53,41" N
Longitude: 3º 48' 14,35" W
Altitude: 690-700 m

View from the west of the modern quarry of Zuhaira.

An example of a saddle quern from the settlement of Los Pensadores, probably originating from a nearby calcareous sandstone outcrop.

Location: The quarry of Zujaira is at the mouth of a ravine a few hundred metres north of the town of Zujaira.

The quarry: Local residents informed me that the quarry provided rock for the construction of the local church. This modern exploitation has left a horseshoe hollow in the ravine and could have destroyed earlier workings.

Prehistoric saddle querns brought to light during the recent archaeological excavations of nearby Late Neolithic settlements of Los Pensadores (1,5 km) and Las Rajas (200 m) (Anderson 2010, unpublished) were possibly fashioned from Zujaira rock. Furthermore, this rock was the basic construction material for at least two oval prehistoric cabins at Las Rajas. About a half dozen prehistoric "beehive" chamber tombs, probably contemporary to Las Rajas (about 200 m away), were carved into the rock farther along the ravine. The cutting of these chamber burials reveals an early mastery over this rock.

Extraction techniques: Rough, angular surface slabs were probably easily detached following the bedding planes from the rock. These extractions would leave little, if any, marks. Larger debris from the cutting of the tombs could have also been used for querns.

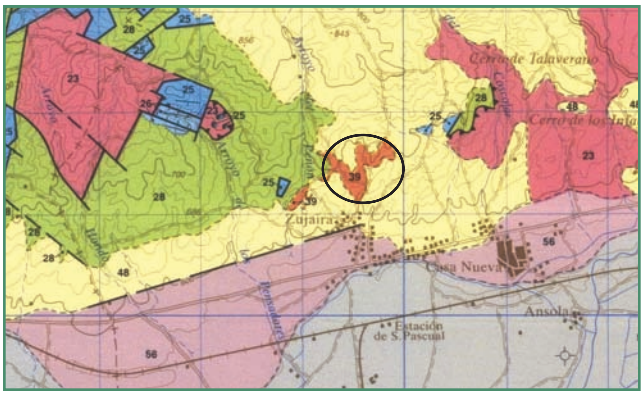
Products, distribution and dating: Besides the prehistoric saddle querns (Late Neolithic), a Roman rotary quern fragment of an identical rock was identified in a wall of the site of El Tesorillo, a Roman Villa about 3 km southwest of Zujaira. We speculate, without any evidence except the petrography, that the hand-quern was also extracted from Zujaira. In any case, neither hypothetical extraction phase (Prehistoric and Roman) would have served more than local needs.

Rock type: Bioclastic calcareous sandstone (Geological map 1009, Granada, 1985). From our observations, the rock is a yellowish homogeneous sandstone.

View from the southeast of the modern quarry (left). In the right in the background is the Prehistoric rock-cut cemetery. In the foreground is a sector of the excavation of the Chalcolithic settlement of Las Rajas.

Orthophoto of town of Zujaira and surrounding settlements: a) the quarry b) Las Rajas c) Los Pensadores and d) the Prehistoric cemetery.

Example of a Prehistoric rock-cut chamber burial.



Extract from geological map 1009 (IGME). The rock exploited is a unit of bioclastic calcareous sandstone (orange). The surrounding yellow unit corresponds to clays, silts and conglomerates .

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GR-13 Otívar

Location: Otívar is a very small town deep in the western Alpujarra mountain range between the city of Granada and the Mediterranean coast. The town is on a steep slope above the Jete River. In spite of our attempts and inquiries with a local historian, we have not identified this quarry. The lack of knowledge of the site among the local population is probably due to extremely the rugged terrain around Otívar.

Source: In his study of the watermills in the Province of Granada, Reyes Mesa (2000) refers to millstone quarries around Otívar. His source is the survey at the end of the 18th century by the geographer and cartographer Tomás López who recorded (but never published) that the Otívar quarries supplied millstones to the watermills along the nearby Jete River.

Transport and distribution: Transport in this rugged terrain would have been difficult. Reyes Mesa observed that this quarry also furnished millstones to many other watermills in the Sierra de Cázulas (Reyes Mesa 2000). These nearby mountains remain, however, in a sphere.

Bread: This quarry is, nonetheless, an important site because it is directly related to the relation between the colour of bread with a specific rock type. According to Tomás López, the quarries of Otívar produced "*piedra basa*" millstones (Reyes Mesa 2000). This term, according to Reyes Mesa, is not related to "*pan baxo*", meaning low, flat bread, but to dark bread ("*moreno*"). This dark bread is baked with "*harina baxa*", that is, flour ground by "*piedras baxas*", a type of rock with rougher texture that during milling does not separate the bran from the flour.

Dating: Production can be dated by Tomas López to the second half of the 18th century (Reyes Mesa 2000).

Rock type: The rock type is not known. The geology of the area is dominated by schists and marbles (Geological map 1055, Motril, 1972). Since these stones are not traditionally exploited for millstones in this area of Spain, it is more probable that the millstone makers exploited outcrops of conglomerate found to the east of the town.

Extract from geological map 1055 (IGME). The town of Otívar is indicated by the arrow. The vast purple and orange rocks are units of marbles and schists. The hatched light green units to the east indicated by the small arrow are conglomerates (the more likely millstone sources).

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GR-14 Ugíjar

Las Canteras

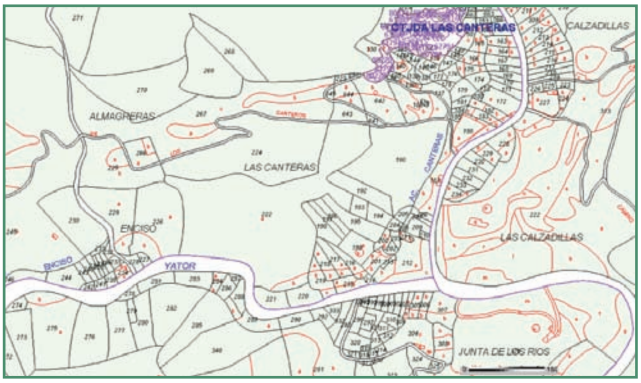
Latitude: approx. 36º 55′ 58,69″ N
Longitude: approx. 3º 2′ 34,85″ W
Altitude: approx. 450 m

Location: The site is in the Municipality of Ugíjar in the Eastern Alpujarra Mountains to the south of Granada at *Las Canteras* (i.e. the quarries), a hamlet three km to the south of Ugíjar. We have not been able to confirm this site in the field.

Sources and toponymy: The reference comes from the study of the watermills of the Alpujarra Mountains by Cara Barrionuevo. The research mentions Ugíjar in passing when referring other nearby millstone quarries at Bayárcal and Darrícal in the Province of Almería (Cara Barrionuevo *et al.* 1999, 153) (see sites AL-6 and AL-5).

An article by Rafael Quesada in the newspaper *El Ideal* places the millstone exploitation to the south of the hamlet, toward the junction of the Ugíjar and Yator Rivers, coinciding with the hamlet called *Las Canteras* (the quarries).

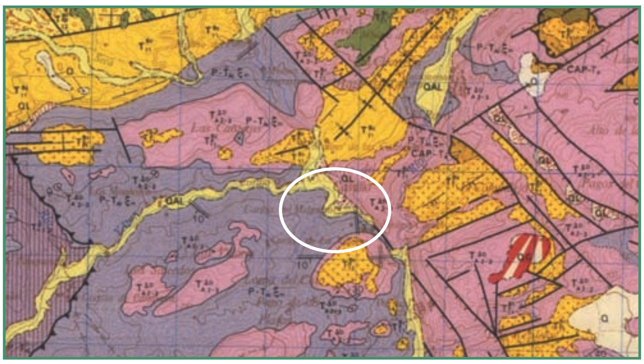
Transport and distribution: Since it would have been extremely arduous to transport millstones over a long distance in this rugged mountainous terrain, we suppose the production was modest, limited to the local demand.



Extract of the cadastre (SEC) indicating the name Canteras.

Dating: The precise date of the production is ignored. It could range from Late Medieval to Contemporary times. The absence of any record in the 19th-century geographical dictionaries suggests that the quarry was either not active or not a major production centre.

Rock type: The material exploited is not known. The potential rock in the area are dolomites and limestone marbles or limestone conglomerates (Geological map 1043, Berja 1977).



Extract from geological map 1043 (IGME). The quarry exploited either a unit of limestone marbles (purple) or limestone conglomerates (dotted yellow).

Source

GAN QUESADA, Rafael, "La Comarca de Ugíjar: Tierra de Contrastes": http://sp.ideal.es/municipios/rutas-com.php?id_ruta=4&id_comarca=3&pageNum_rutas=8 [accessed February 2,2012].

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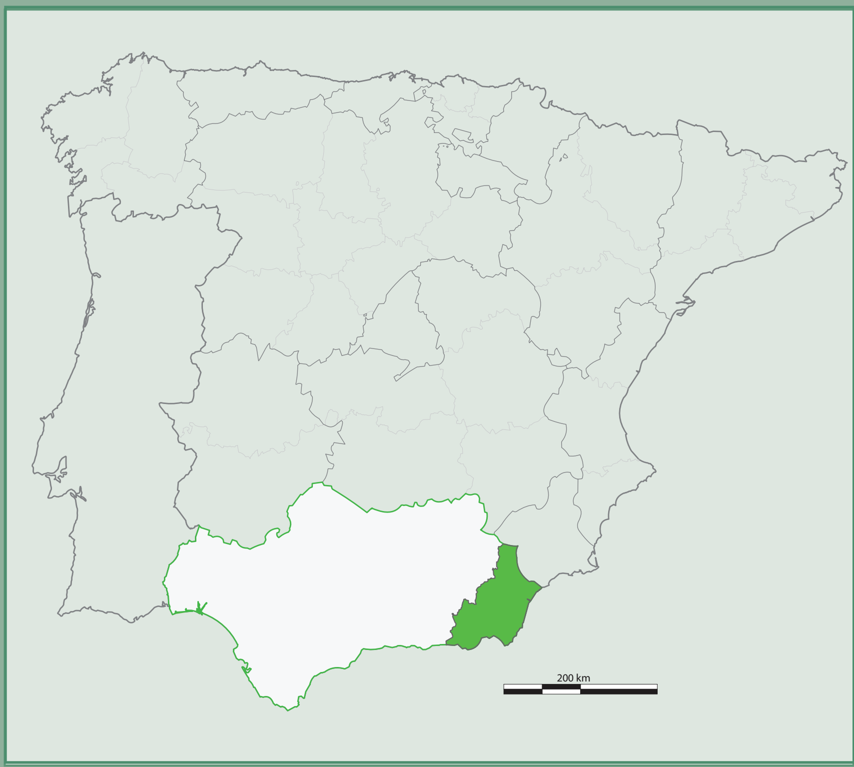
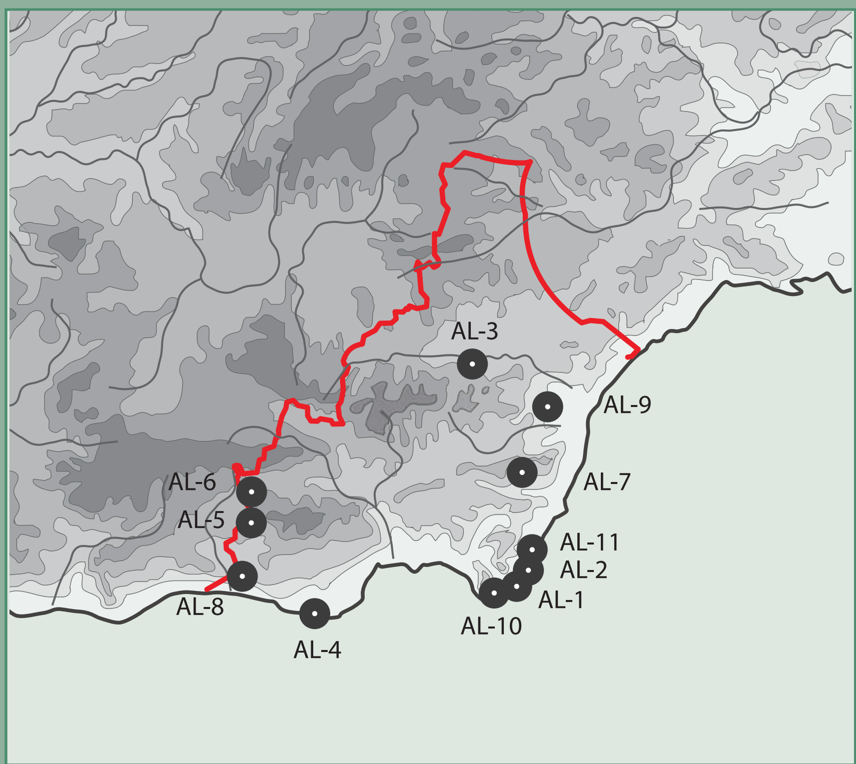
ANDALUSIA
ALMERÍA (AL)





AL-1 Níjar

Cerro de Limones

Latitude: 36° 48′ 35.45″ N
Longitude: 2° 6′ 46.06″ W
Altitude: 365 m

View from the south of the Cerro de Limones. The Garbanzal caldera is in the background (to the left).

Location and sources: The Roman quern quarry of Cerro de Limones is located in the southeastern volcanic district of the Iberia Peninsula in the Cabo de Gata Natural Park. The site, an hour hike uphill from the town of Presillas Bajas, on the southern plateau of the Cerro de Limones mountain, beside the Garbanzal volcanic dome. Although protected in the National Park, the site has suffered from years of plundering. Most of the better conserved querns decorate the gardens of houses in the neighbouring towns.

This is the first Roman quarry identified in the field in the Iberian Peninsula. It has been presented in the proceedings of two recent colloquia (Anderson *et al.* 2011; Anderson 2011: 265) and to our knowledge, is not cited in any other previous written source.

Toponymy: The name Limones sparks is curious at this location. Lemons do not grow in this arid climate. If by chance at some point there was an inversion of the first two syllables of "*limones*", the original name would have been "*molinos*" (mills).

The quarry: The site is littered with hundreds of broken or unfinished rotary querns and working debris. The quern makers had the choice of working either surface blocks collected from the nearby scree and talus or detaching blocks from the bedrock. Part of this extraction process could have taken place along the mountain slope where columnar jointing is still visible. Another part certainly took place on the top of the mountain where blocks were extracted from what is possibly the summit of columnar jointing, resulting in a few large pits (probably less than 1 m deep).

View from the northeast of the plateau on the top of the Cerro de Limones. Several large and shallow pits coupled with concentrations of working debris are interpreted as workshops where the querns were knapped into shape.

Technique: After detaching (probably with levers) or collecting surface material, querns were fashioned (either by knapping or with a hammer and chisel) into a rough cylindrical shape. The eye of upper stones (*catilli*) were perforated at the quarry itself, a step that resulted in many breaks. There is also evidence that radial handle fittings were also cut at the site. The protuberance of lower stones (*metae*) was also roughly knapped into shape resulting in a shape like a Mexican sombrero. There is no indication, however, that the eye of the lower stone was hollowed at this stage. The process of fashioning produced tons of flakes concentrated, for the most part, in the working areas, but also over the whole of the top of the hill.

Product and quantification: The production consisted exclusively of rotary querns measuring between 35 and 42 cm in diameter. There are hundreds of fragments both on the top of the hill and on the slope on the southern side overlooking the coastal town of San José. There are also many quern fragments now decorating the houses of the nearby town of Presillas Bajas, as well as other country houses in the area.

Considering the high number of discards, the original production could have attained the thousands. Based on the size and the fittings, production of these querns appears to be standardised. There is no evidence of any other type of mill (for example ring mill) other than that of the small hand-operated rotary quern.

Transport and distribution: The proximity of the Mediterranean coastline (4 km) marked with its small bays where boats could have docked would have facilitated the transport of these querns up and down the coastline. The extension of the distribution of this product, a project that must be pursued, is still not determined. In any case, the great number on the site suggests a wide distribution. The quern makers could have easily benefited from well-established ancient trade routes both to southern Iberia and beyond.

A high concentration of roughouts on the southeastern slope, to the south of a sharp ravine, suggest that the stones were hauled down this smooth slope toward the coast. There is, however, no evidence of any ancient path.

Dating: The production dates, according to its typological features (radial handle fittings and protuberance around the eye of the lower stone), to Roman times. Many similar querns are known to light in Roman contexts are known in museum depositories throughout the south of Spain.

Rock type: The rock is a reddish-brown, hard and slightly porous biotite dacite (Geological Map 1060, Poza de los Frailes, 1978). Samples from this site have been the subject of geochemical analyses (Anderson *et al.* 2011).

Talus containing abandoned querns along the southwest slope. The Mediterranean Sea is in the background.

Columnar jointing on the slope.

View of a large shallow pit filled with working debris interpreted as pit quarry.

Examples of abandoned rotary querns on the plateau of the Cerro de Limones. The stones assembled for a plunder that did not take place.

Abandoned rotary querns. Upper stone eyes are pierced. Lower stones bear a central protuberance. These fragments were probably gathered to be plundered.

Detail of a concentration of working debris interpreted as a workshop.

Examples of discarded rotary quern fragments.

An example of a cylindrical blank destined to be an upper stone.

The piercing of the eye of the upper stone took place from both surfaces.

Example of a broken upper stone. This quern is located on the southeastern slope of the mountain.

Example of an abandoned cutting of a radial handle slot.

View of an abandoned lower stone with its central protuberance.

*View of an abandoned lower stone (*meta*).*

View of a house in the town of Presillas Bajas decorated with rotary querns from the Cerro de Limones quarry.

Extract from geological map 1060 (IGME). Biotite dacites (light green).

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Acknowledgements

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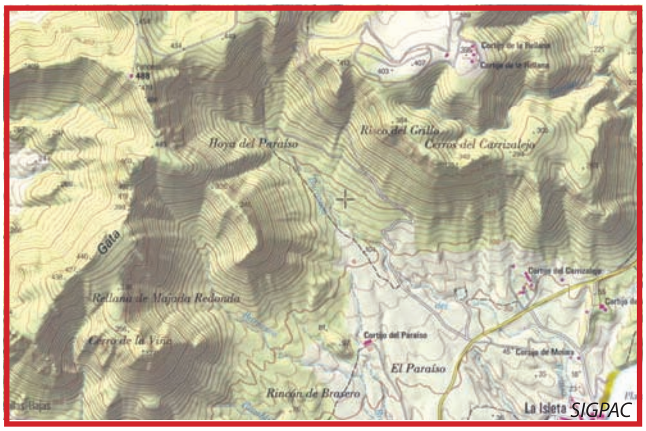
AL-2 Níjar

La Hoya del Paraíso

Latitude: 36° 49′ 23.31″ N
Longitude: 2°4′ 0.60″ W
Altitude: c. 90-120 m



View from the west of the valley floor with the parallel lines of retaining walls. The Mediterranean Sea is in the background.

Example of an abandoned rotary quern roughout in the Hoya del Paraíso quarry.

Location: The Roman rotary quern quarry of the *Hoya del Paraiso*, like the exploitation of *Cerro de Limones* 4 km to the southwest, is in the southeastern volcanic district in the Cabo de Gata Natural Park, between Caldera of the Majada Redonda, one of the more visible volcanic craters of the district, and the Isleta del Moro, a small fishing town on the Mediterranean Sea.

The quarry: This site is not centralised in a single sector, but spread over a vast surface comprising both the valley floor and slope of the hill to the east leading to the Majada Redonda caldera. In this sense, it differs from the nearby Cerro de Limones quarry, that is concentrated on the top of the mountain (see AL-1).

The most visible sector is on the valley floor. Quern production is evidenced by a large number of unfinished or broken querns strewn about the surface. Many are now recycled in a series of parallel ill-constructed linear features, possibly retaining walls for agricultural fields.

From the large number of abandoned querns still in the field, in addition to the better preserved pieces that were moved to a nearby townhouse, we can deduce that the bottom of the valley was once the location of a large workshop where blocks were gathered and fashioned into querns.

In contrast to the Cerro de Limones, there is no evidence of extraction in pits in the area. The querns appear to have simply been collected on the surface among the scree on the valley floor or possibly from columnar jointing further up the hill to the east of the valley. The valley, however, is very large and has not been systematically explored. Further systematic field work will certainly bring to light more information about extraction techniques and the organisation of the quarry.

Product and quantification: The type of quern produced at this site is identical to that of the Cerro de Limones, i.e., upper stones with pierced eyes and lower stones with the protruding knob on the top around the future eye of the spindle. As in the case of Cerro de Limones, there is no evidence of production of any other type of millstone at this site. In terms of quantity, although production must have been in the hundreds, possibly more, it appears to be more modest than that of the Cerro de Limones.

Transport and distribution: The proximity of the Mediterranean Sea, less than 2 km away, would certainly have facilitated the distribution of these products up and down the coastline. Like the Cerro de Limones, production would have benefited from the long-standing network of Antique trade routes.

Dating: Based on the observation of identical querns from Roman contexts stored in museum depositories, the production is Roman.

Rock type: Dacite-rhyolite (Geological Map 1060, Poza de los Frailes, 1978). Reddish-violet surface, but interior is light grey. Not highly vesicular. On the surface, the appearance is identical to the production of Cerro de Limones (AL-1).

View from the east of the Hoya del Paraíso. Abandoned querns are found on this slope.

Columnar jointing on the hill adjacent to the Majarda Redonda caldera.

Example of a broken upper stone quern placed in an old retaining wall on the valley floor.

Detail of a retaining wall on the valley floor containing abandoned quern fragments.

Detail of abandoned querns on the valley floor.

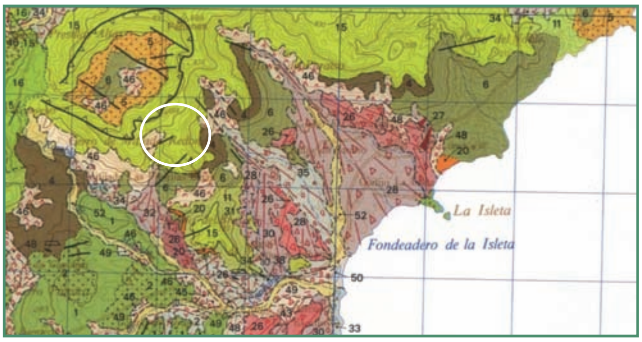
Detail of abandoned querns on the valley floor.

Detail of an abandoned cylindrical blank on the valley floor.

Detail of a broken cylindrical blank on the valley floor.

*Detail of a broken upper stone (*catillus*).*

Detail of an abandoned sombrero *type lower stone (*meta*) on the slope of the hill.*



Extract from geological map 1060 (IGME). The Majada Redonda volcanic caldera is to the west of the site. The querns are found in the dacite-rhyolite unit (brown, 4) and in the biotite dacite - red violet amphibolite unit (light green, 15).

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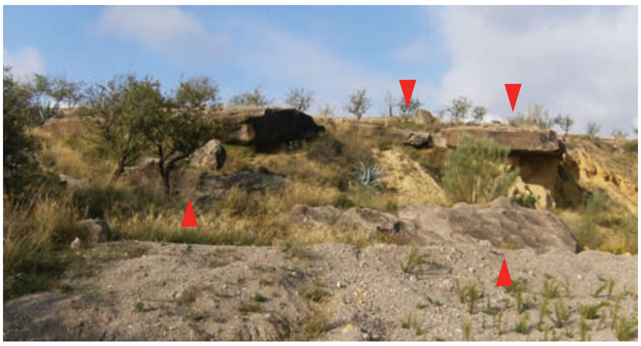
AL-3a Albox

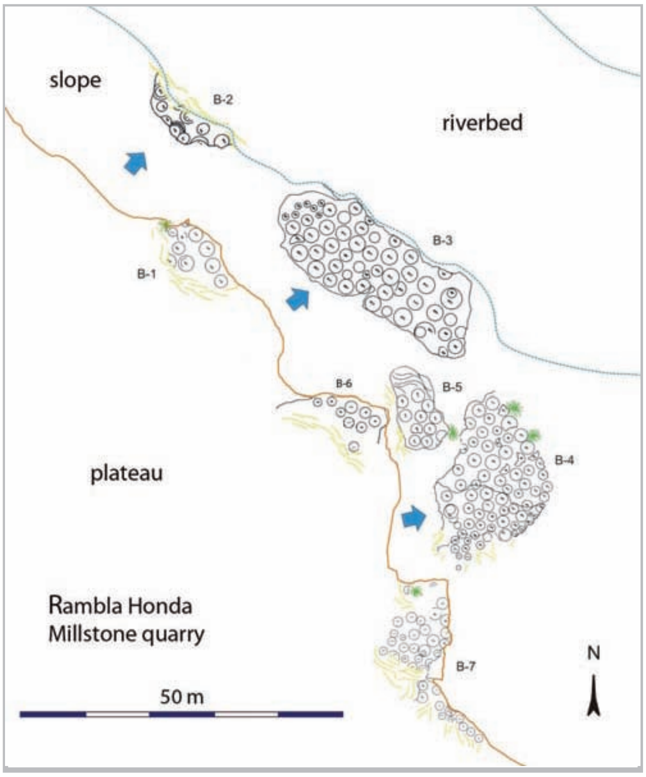
Cantera de la Rambla Honda

Latitude: 37° 24′ 18.99″ N
Longitude: 2°7′ 18.19″ W
Altitude: 460 m

View from the northeast of the central area of sector 1 of the millstone quarry (photograph by F. Martínez).



View from the east of a part of sector 1. The downward-facing arrows indicate blocks in their original position on the plateau. The upward arrows indicate displaced blocks.



Sketch of Sector 1 of the Rambla Honda quarry (from Martínez et al. *2011). The arrows indicate the blocks that have been displaced from their original position.*

Location: The quern and millstone quarry of the *Rambla Honda* (deep, dry riverbed) is in the heart of the wide and flat Almanzora valley about 2 km northeast of the city of Albox. It is found along a dry riverbed that winds through the region.

Sources: An article about this site appeared in the transactions of a molinological conference. This is the first millstone quarry in southern Spain to be the subject of a specific publication. Since this first publication, the site has been re-examined and published a second time (Martínez *et al*. 2011).

The quarry: The exploitation consists of two main sectors. Sector 1, to the south (100 x 30 m), by far the largest, is a true extractive surface quarry spread over 7 large blocks. The contiguous extraction hollows follow horizontal planes on one, rarely two, levels. Several of the blocks have been detached from a main stratum of bedrock along the upper plateau by torrents that periodically rush through the riverbed during flooding. They have either slid to their current resting place on the slope or directly on the edge of the riverbed. The latest disaster of this type dates to 1970.

The second sector is found about 100 m to the north on the other side of the riverbed and comprises only a few "isolated" extractions.

Techniques: Tool marks are rarely visible so it is not possible to identify the extraction techniques with precision. We suppose the trenches around the cylinders were cut with pick. Wedge holes, in a few instances, are carved at the base of a cylinder. We ignore, however, if the wedges were of iron or wood.

Products and quantification: The site produced a variety of cylinders of different size from small rotary querns about 40 cm in diameter to large cylinders up to 1,40 m in diameter. Of the approximately 150 extractions sufficiently clear to measure, four cylinder sizes are more frequent (A: 40 cm; B: 90 cm; C: 1,10-1,20 m; D: 1,30 m). The most common size of by far, with about 30 examples, is that of 1,10 m. This corresponds to millstones destined to either local or regional animal-driven mills, windmills or watermills.

Transport and distribution: The Almazora Valley is wide and their would have been no obstacles for distribution. The number of extractions suggest more than a local production.

Dating: The precise date of the quarry is not certain. Although the differences of diameter suggest different phases of work, this cannot be proved. On the large displaced block (B-3), now in the riverbed, extraction hollows are on two different extraction planes suggesting two phases of work. The marks on what is now the diagonal face, and partially covered by alluvial deposits, probably date to when the block was in its original horizontal position on the plateau. The horizontal extractions today on the summit of the block, on the other hand, probably took place later, after the block was displaced.

The small concentration of rotary quern extractions on the northern western edge of Block 3 could be interpreted as the initial phase of work, probably Medieval since conglomerate is not usually exploited in Roman times. This dating would seem to be corroborated by handmill extractions elsewhere at the site, interspersed with the larger hollows, as if they were extracted at the same time. The medium-sized extractions (80-90 cm) also point to a Medieval date. The largest extractions, well over a metre, could also be Medieval or represent a later extraction phase (Modern or Contemporary).

Rock type: Conglomerate with large rounded clasts (Geological map 996, Huercal-Overa, 1978).

Detail of the northwestern end of block 3 where both small rotary querns and millstones were extracted.

Panoramic view of the detached block (B-3) partially buried in the alluvial deposits in the riverbed. The smaller handmill extractions are to the right (photograph by F. Martínez).

View of block 2, displaced by a torrent into the riverbed.

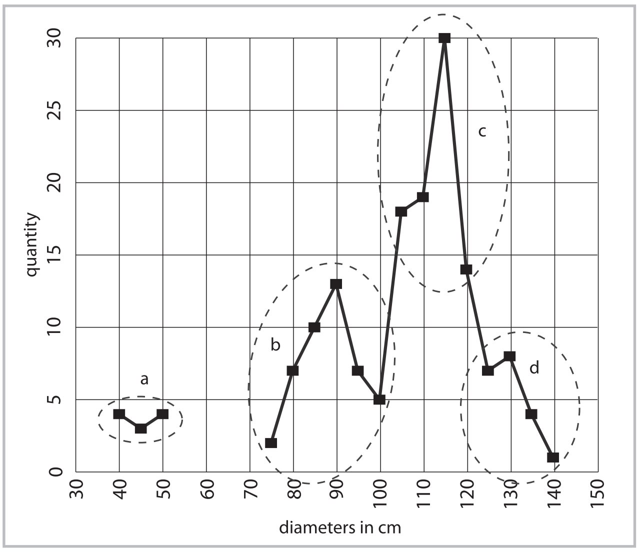
View of block 2 with wedge holes along the base of several extraction hollows.

Detail of a wedge hole.

Extraction hollows following 2 different extraction planes (horizontal on summit, diagonal on inclined face) suggesting 2 chronological phases of work.

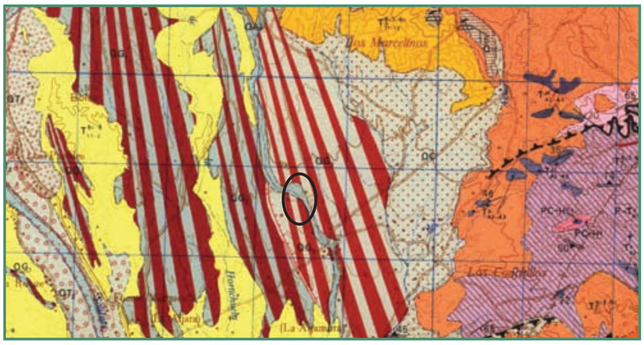
View from the south of sector 2 of the quarry.

Detail of the extraction hollow of Sector 2.



Line graph of the quantity of millstones extractions according to their diameter measured in cm (from Martínez et al. *2011).*

Detail of the rock indicating the form of the clasts.



Extract from geological map 996 (IGME). The quarry exploited a conglomerate unit (beige - QG2). Red stripes represent a glacial pavement.

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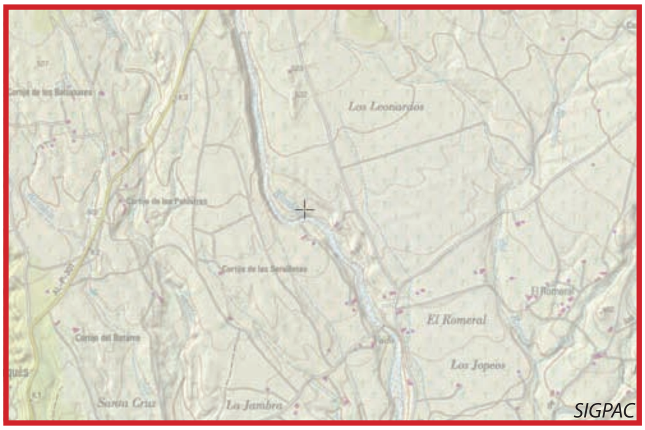
AL-3b Albox

Los Leonardos

Latitude: 37º 24′ 33.07″ N
Longitude: 2º 7′ 30.32″ W
Altitude: 485 m



View from the north of a sector of the quarry of Los Leonardos. To the left can be seen an unfinished trench for a block.

Location: The Leonardos quarry is about 200 m north of the Rambla Honda at a large bend of the ravine. Most of the extraction in this area is of building blocks that from oral tradition date to the middle of the 20th century (Martínez pers. comm.).There is also a modest millstone production.

The quarry: The site appears to be a surface quarry limited to several small bedrock outcrops.

Products and quantification: There are six cylinders or extraction hollows corresponding to millstones measuring 70 and 130 cm destined for animal-driven mills, windmills or watermills.

Transport and distribution: This production is probably contemporary to that of the Rambla Honda and would have benefitted from its network of distribution.

Dating: The medium-sized models (70 cm) are probably Medieval while the large models are Contemporary.

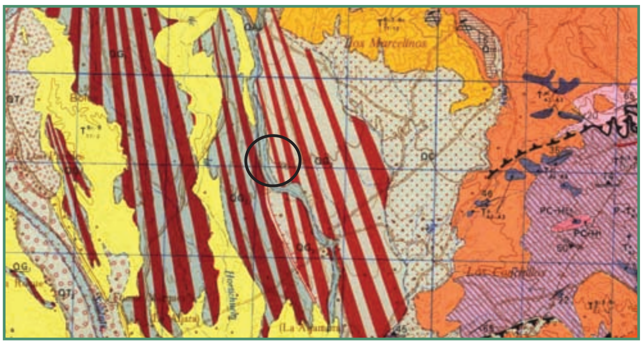
Rock type: Conglomerate with large rounded clasts (see AL-3a).

View of a block containing several large extraction hollows corresponding to millstones about 1,30 m in diameter..

Detail of an unfinished millstone measuring 1,30 m in diameter.

Detail of an abandoned millstone measuring 1,30 m in diameter.

Detail of an abandoned cylinder measuring 70 cm in diameter.



Extract from geological map 996 (IGME). The quarry exploited a conglomerate unit (beige - QG2). The red stripes represent a glacial pavement.

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AL-4 El Ejido

Guardias Viejas

Latitude: 36º 41’ 59. 82” N
Longitude: 2º 51’ 5.88” W
Altitude: 20 m

View from the north of the conglomerate outcrop. The millstone extractions are clustered toward the end of the outcrop. In the background is the Mediterranean Sea.

Location: The site of Guardias Viejas is located on the coastline of the Bahía del Castillo near a fortification dating to the 18th century.

Source: It is identified in a molinological study (Cara Barrionuevo *et al*. 1999: 154). We have not identified any old written source.

The quarry: It is a very modest site, halfway between a pocket quarry and an edge quarry with about a dozen extractions hewn directly from the bedrock. The horizontal hollows are on tiers and in only one case are superimposed. In spite of a its eroded surface, it is possible to observe the parallel diagonal lines on the quarry faces indicating that the trenches around the cylinders were cut with picks.

Products and quantification: Extractions measure between 1,25 and 1,40 m. The site includes only 8 extraction hollows and 2 abandoned millstones.

Transport and distribution: The millstones could have travelled either by land or by sea. The site only served a local demand.

Dating: Medieval to Contemporary.

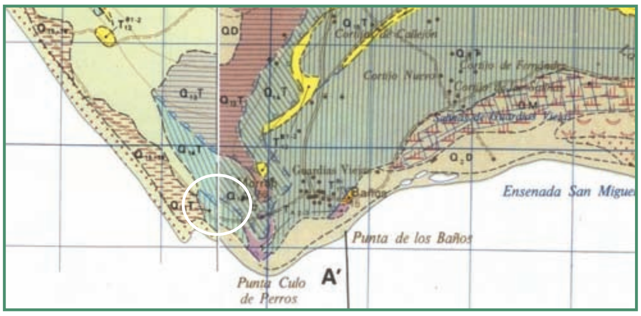
Rock type: Conglomerate (Geological map 1057, Adra and 1058 Roquetas del Mar). The workers concentrated work in a sector of the outcrop with round small, regular pebbles (up to 2 cm), mostly fine-grained quartzites in a matrix of sand and calcite (petrographical description by T. Grenne (NGU).

Orthophoto of the site (SIGPAC). The quarry is at a conglomerate outcrop between the fortification and the coast.

View of the quarry from the southwest.

View of the quarry from the north.

Detail of an unfinished cylinder.



Montage of extracts from the geological maps 1057-1058 (IGME). The quarry exploited a unit of conglomerate (light green).

Detail of the quality of the rock.

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Acknowledgements

I thank Tor GRENNE of the Geological Survey of Norway (NGU) for accompanying me to the site and defining the rock.

AL-5 Alcolea

Barranco Baena-Barranco Pedreros

View from the west of the Baranco Baena from the road AL-6400 (from Google Maps Street View).

Location and toponymy: The Barranco Baena is in a steep and rugged ravine running westward into the Adra River Valley just to the north of the Benímar Dam. There is a discrepancy between the different maps consulted. In the geographical map *(SIGPAC)*, the Barranco Baena is a ravine to the east of the road liking Darrical and the coast. The ravine in the cadastral map (*SEC*), however, is about 400 m to the south. The more northern ravine in this second source is called the *Barranco de los Pedreros* (Ravine of the quarry men) and ends to the east at the place name *El Pedregal* (terrain of loose stones). The names are perfectly compatible with millstone production.

Sources: Millstone production from the *Barranco Baena* is cited in two studies of millstones (Rodríguez Monteoliva 1989; Cara Barrionuevo *et al*. 1999: 153).

Products and quantification: Millstones for watermills. The quantity is unknown. The study by Rodríguez Monteoliva (1989: 705) indicates that millstones from the Barranco Baena were "*bazas*" (i.e lower stones) and that upper stones were brought from Moclín (see GR-1).

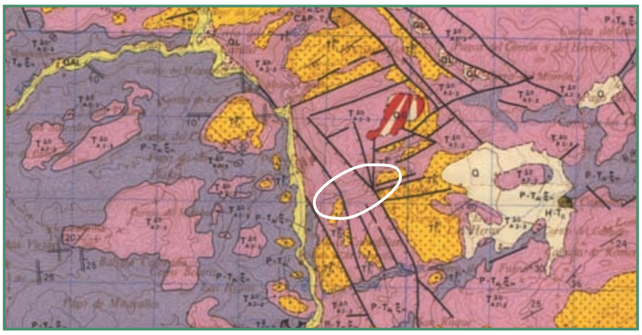
The quarry: The ravine is full of loose surface boulders. Since we have not surveyed the quarry, we do not know if the quarrymen extracted the millstones directly from bedrock or if they simply fashioned surface material.

Transport and distribution: The quarry was connected to the hamlet of Darrícal by means of a narrow path or lane (Cara Barrionuevo *et al*. 1999: 153). Rodríguez Monteoliva (1989: 705) mentions the technique of "rolling" the millstone with axle in the middle of the eye from the site to the nearby towns. According to Cara Barrionuevo and his team (1999: 153), this quarry equipped the watermills of the towns of the central Alpujarra Mountains.

Dating: Medieval to Contemporary.

Rock type: The rock is a conglomerate made up of metamorphic and quartz clasts in a calcite matrix that also includes fossils (Cara *et al*. 1999: 153). The geological map indicates, besides conglomerates, the presence of limestones and sandstones in the ravine (Geological map 1043, Berja, 1977).

Cadastral maps (SEC) of the Barranco Baena area. *The map to the right is the detail of the rectangle highlighted on the first map. The place name* Barranco Baena *in this map differs by several hundred metres (to the south on the left map) from that of the geographical map (SIGPAC). In the cadastral map, the ravine is the* Barranco de los Pedreros *(Ravine of the quarry men)* and El Pedregal (an area of surface stones)*, names consistent with millstone production.*



Extract from geological map 1043 (IGME). The pink unit is marble limestone and dolomites. The rock exploited for mill-stones, according to Cara Barrionuevo (1999), corresponds to the orange spotted unit of conglomerates.

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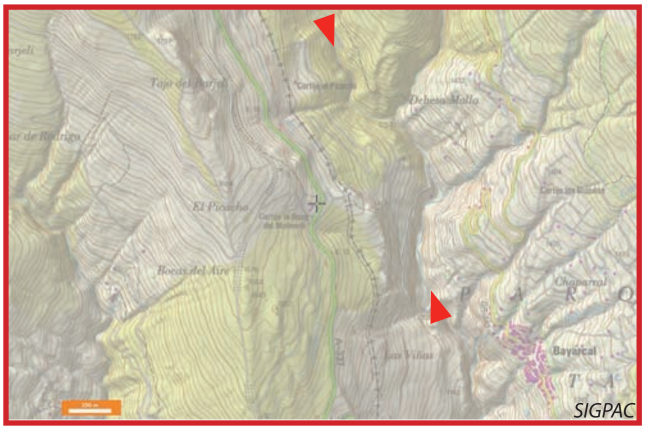
AL-6 Bayárcal

Barranco de Palancón



Location and source: The millstone quarry of the *Barranco de Bayárcal* (Ravine of Bayárcal) is in the heart of the Sierra Nevada Mountain National Park near the mountain pass of Puerto de la Ragua. The ravine (*barranco*) runs north to south for about 2 km. Although Cara Barrionuevo and his team state that it is perched above the watermills of the town of Bayárcal (Cara Barrionuevo *et al*. 1999: 153), we have not been able to pinpoint the site.

Toponymy: To the east of the ravine is an area with the place name *Dehesa* (meadow) *Molla* that could be a derivative of *mola* from the Latin "mill".

Dating: Medieval or Contemporary.

Rock type: The Palancón ravine is dominated by mica schists (Geological map 1028, Aldeire, 1978) The rock exploited is uncertain.

Extract from geological map 1028 (IGME). The violet unit corresponds to schists. We ignore if this is the rock exploited, or if there is another outcrop in the area that is not indicated on the geological map.

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AL-7 Sorbas

Los Loberos

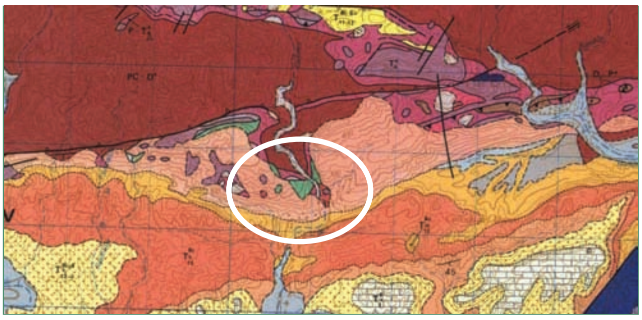
View from the south of the Loberos hamlet.

Orthophoto of the hamlet of Loberos (SIGPAC).

Location: Loberos is a hamlet on a steep slope on the southern fringe of the Sierra de Cabrera Mountains in the north of the Almería Province. It is 12 km southeast of the town of Sorbas. The exact location of the quarry is not known.

Source: The only mention of the millstone quarry of *Los Loberos* is a passing reference in a study of watermills of the Níjar region (Torres Montes 1993: 272).

Toponymy: The are several places in the mountains in the surrounding area to the northwest of Loberos associated with the name *Molata*, possibly a variation of *moleta*, meaning a stone for grinding pigments or for pharmaceutical use. However, we cannot assure that this is related to the millstone quarry.



Extract from geological map 1031 (IGME). The reddish units are varieties of schist. The green unit a carbonate rock.

Dating: The source provides no information about the date of the site. Since its products were meant of recent watermills, its date can range from Medieval to Contemporary times.

Rock type: The rock type is not known. It is not volcanic since Loberos is beyond the northern extension of the Cabo de Gata volcanic district. The site is in fact somewhere along the border of the Alpujárride and Nevado-Filábride geological complexes in a sector dominated by schists and micaschists. It is however more likely that the quarry exploited a local sedimentary outcrop, possibly the green carbonate rock, since we have never observed Contemporary millstones of schist or micaschist in the south of Spain (although schist is a well-known source in Central and Northern Europe, for example, in Norway).

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AL-8 Adra

Cerro el Chispas

Latitude: 36º 45′ 33.79″N
Longitude: 3º0′ 13.45″W
Altitude: 40-50 m

View of the western slope of Cerro el Chispas with an outcrop of a layer of conglomerate.

Location: The Cerro el Chispas quarry (or simply Cerro Cantera) is located to the northeast of the coastal city of Adra on the western slope of a foothill bordering the coastal plain.

Sources: Madoz, in his description of the productions of Adra more than a century earlier, refers to a millstone quarry "half an hour to the east" of Adra (Madoz 1845, Vol. 1: 88). This allusion coincides roughly with the quarry of Cerro el Chispas.

The site is described by the team of Cara Barrionuevo (1999: 153) as an open-air quarry with four unfinished millstones cut directly into the bedrock and separated by a trench measuring 14 cm wide. The author estimates that about 30 millstones were extracted.

The quarry: Unfortunately, during our visit, we were not able to identify the site described by Cara Barrionuevo. With the large amount of construction since the 1990s, this sector of the site has possibly been destroyed. There are, however, two small extraction hollows along the edge of the conglomerate layer that could correspond to rotary quern hollows. Elsewhere along the western and southern slope there are several craters surrounded by what appears to be spoil heaps. These could be vestiges of millstone pit quarries.

Products and quantification: The 1999 research team records that the four abandoned millstones measure between 1,00 and 1,20 m in diameter.

Distribution: From the number of extractions the site probably served local demand.

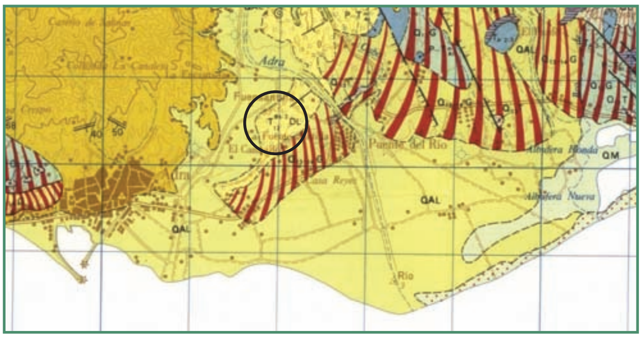
Dating: Based on the diameter of the larger millstones (1,00 and 1,20 m) and the 1845 reference by Madoz, the site dates from Contemporary times. The smaller 40 cm extraction hollows suggests a Medieval phase.

Rock type: Conglomerate with large rounded pebbles (Geological map 1057, Adra, 1983). Conglomerate from the Tertiary (Cara Barrionuevo *et al.* 1999: 153).

One of several large pits. The exposed rock shows signs of trenching. It is possible that millstones were extracted from this pit along vertical planes.

Detail of the cuttings of the outcrop at the base of the pit.

Two extraction hollows corresponding presumably to rotary quern extractions.



Extract from geological map 1057 (IGME). The yellow unit corresponds to conglomerates, sands and silts.

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MADOZ, Pascual. *Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar*, Madrid, Vol. 1. 1845.

AL-9 Vera

SIGPAC

Location: Vera is in the northernmost municipality of the Almería Province. It is along the Mediterranean coast and covers a surface of almost 60 km2. Although it contains some elevations with potential outcrops, most of the area falls into to the flood plain of the Almanzora River.

Source: The only information of millstone production here is in a brief reference by Madoz (1850, Vol. 15: 670). The geographer simply states that one or more millstone quarries are located in the Municipality and they produce *ruedas de molino* (mill wheels).

The quarry: We have not been able to identify these sites in the field. We would suspect that they are at the outcrops on one of the hills or, like other cases or quarries notably Caniles (GR-11) and the Rambla Honda (AL-3), along a stratum of rock exposed along the edge of a riverbed. Since the local molinologist is not aware of these exploitations, it is very possible that they are covered or have been destroyed by later quarry work or construction.

Product: The term *ruedas de molino* suggests products destined for flour mills and not *almazara* (oil mills).

Dating: Middle of the 19th century.

Rock type: Judging from the Contemporary date, the quarrymen most likely exploited sedimentary rocks (conglomerates or sandstones) and not volcanic material, a rock type present in the municipality.

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AL-10 Níjar

El Barronal

Latitude: 36º 44′ 9.97″ N
Longitude: 2º 7′ 18.30 W
Altitude: c. 30 m

View from the north of the Barronal point.

Location: The Barronal quarry is associated with Chalcolithic and Bronze Age settlements identified during a surface survey in the southeastern point of the Cabo de Gata Natural Park. The site is on a volcanic mound that juts into the sea.

Source: The stone workings are identified in several archaeological articles about the exploitation of georesources in the Cabo de Gata in Late Prehistory (Carrión *et al.* 1993).

Extract from geological map 1060 (IGME). The quarries are found in brownish unit of rhyodacites.

Quarries: Small pit quarries exploiting the summit of volcanic columnar jointing.

Products and distribution: Saddle querns and other stone tools. Manuel Ramos, of the Archaeological Museum of Almería, has informed me that querns of volcanic rock (as well as garnet schists) are known at the Chalcolithic settlement of Los Millares about 50 km to the west. It is not possible, however, to affirm that the volcanic rocks come from this site.

Dating: Chalcolithic and possibly Bronze Age.

Rock type: Rhyodacite (Geological map 1060, El Pozo de los Frailes, 1983).

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Acknowledgements

I thank Manuel RAMOS of the Museo Arqueológico de Almería for pointing out the existence of this site.

AL-11 Níjar

Rodalquilar district

Detail of the upper most rotary quern blank that, due to its dark colour, suggests the presence of a third Roman quern quarry in the Cabo de Gata district.

Location and generalities: A stack of 9 whole or fragmented Roman rotary querns roughouts and blanks cemented together decorates a street in the town Rodalquilar. This town is situated in the heart of the Cabo de Gata volcanic district.

All of these querns resemble the productions identified at Cerro de Limones (AL-1) and Hoya del Paraíso (AL-2) just a few kilometres to the south. The sole exception is the uppermost cylindrical blank measuring 40 cm in diameter. Its colour, grey to black, different from that of the known local reddish-brown productions, points to a third Roman quern production in the Cabo de Gata.

Dating: Roman

Rock type: Volcanic.

Acknowledgements

I thank D. Peacock of the University of Southampton, UK, for his observations.

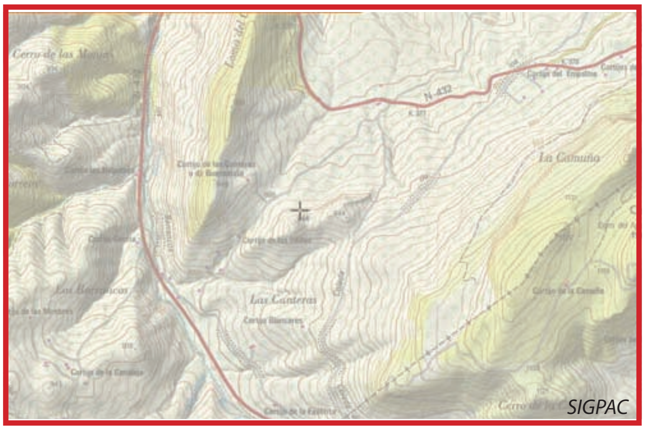
ANDALUSIA

JAÉN (J)

J-1 Castillo de Locubín

Las Canteras

Latitude: 37º 30′29,90″N
Longitude: 3º 58′8,71″W
Altitude: 900-910 m



View from the southwest of the millstone quarry of Castillo de Locubín.

Location: The *Canteras* quarry is in the southwestern corner of the Municipality of Castillo de Locubín along a ravine, uphill from the main valley linking the cities of Castillo de Locubín and Alcalá la Real.

Sources: There are several references to a "*Canteras"* millstone quarry in this area. The first dates to 1792 and indicates the manufacture of millstones of various sizes (*Encyclopedia Moderna* 1792: 461). The second is a brief note in a geographical dictionary (Miñano 1826, Vol. 2: 477). Neither of these record the site's precise location. Twenty years later, the location of the *Canteras* quarry is specified at the base of the *Acamuña* (today *Camuña*) Mountain (Madoz 1845, Vol. 1: 382). The geographical information by Madoz is accurate except that the site is not in the Municipality of Alcalá la Real but in Castillo de Locubín. The error is likely due to the proximity (500 m) of the border between the two municipalities. A fourth written source, 20 years after the Madoz, is a list of products from Castillo de Locubín presented in 1867 at the Universal Exposition of Paris (*Catálogo General de la Sección Española* 1867: 190).

Toponymy: The place name *Canteras* (quarries) is common for both quarries and millstone quarries.

The quarry and techniques: The exploitation is set along the northwestern base of a cliff. The quarry is the only site, to our knowledge, that combines three techniques of extraction. A small sector corresponds to an edge quarry where millstones were scored directly from the rock face at the base of the cliff leaving several vertical extraction hollows. A second sector has millstones hewn from large surface blocks, accumulated in a talus along the base of the slope. A third extraction technique is that of detaching angular blocks from the cliff face.

Products and quantification: The abandoned cylinders measure between 1,10 and 1,30 m in diameter. We suppose that item no. 84-263 displayed at the Universal Exposition of Paris in 1867 at the price of 70 *escudos* (Comisión Régia, *Catálogo* 1867: 190) corresponds to this model.

In is noteworthy that among the discarded millstones along the slope, there is also a small rotary quern blank measuring 50 cm in diameter.

Transport and distribution: The position of the site along the N-S road valley between Castillo de Locubín and Alcalá la Real would have facilitated transport. The display of a millstone, presumably from this quarry, in the Universal Exposition of Paris suggests the product was quite coveted and probably was marketed throughout the region or beyond.

Dating: The written sources place production from the end of the 18th century throughout the 19th century. The small rotary cannot be dated precisely. From its size (about 50 cm), it appears to be Medieval. It could also be a blank for a Contemporary animal fodder quern.

Rock type: Calcarenite, breccia and conglomerate (no. 28) and loams (no. 29) (Geological map 968, Alcaudete, 1988). From our observations the rock is yellowish, coarse and homogeneous, probably a calcarenite.

View from the west of the quarry of the Castillo de Locubín quarry. In the forefront is the talus exploited as surface blocks and in the background is the cliff that was exploited by both true extraction (vertical hollows) and by detaching angular blocks with levers.


Views of vertical circular extractions along the base of the cliff.


View of the base of the cliff. In this sector, angular blocks were detached with levers from the rock face by profiting from natural fissures.

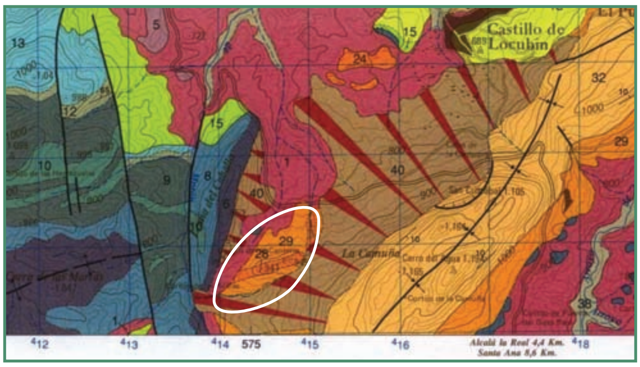

View from the west of the talus and working debris.

Views of abandoned millstones in different stages of manufacture.

Millstone propped upright during the final phase of fashioning. The original yellow colour of the rock is conserved because it is sheltered from weathering by an overhanging rock.

Lateral view of the millstone that was abandoned after fashioning one face.

Views of a small rotary quern blank measuring 50 cm in diameter.



Extract from geological map 968 (IGME). The quarry exploited unit 28 (darker orange), a unit of calcarenite, breccia or conglomerate. The surrounding lighter orange unit (no. 29) corresponds to varieties of loam.

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Acknowledgments

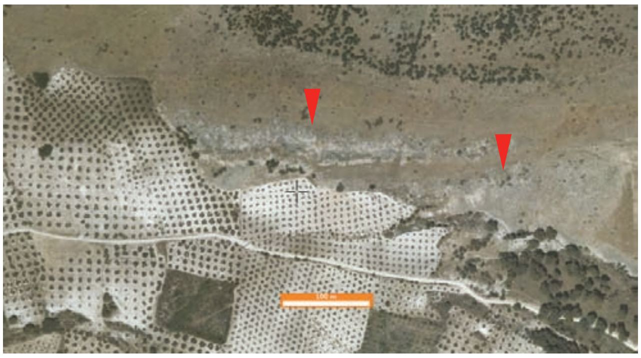
I kindly recognise José MARQUEZ, a neighbour of the quarry, for leading me to the site.

J-2 Jimena

El Lachar

Latitude: 37º 49' 19.98" N
Longitude: 3º 29' 29.50'' W
Altitude: 950-980 m

View of site's location from the southeast.



Orthophoto of the two parallel quarry trenches (SIGPAC).

Location and generalities: The millstone quarry of El Lachar (at times written Lanchar) is in the Natural Park of the Sierra Mágina, perched on the flat upper plateau of an elongated mountain above the town of Jimena. To the southeast of the plateau, along a steep ravine, are what the locals call the "*viejas canteras*", corresponding to the old millstone exploitation. The site is not to be confused with a modern (probably 20th century) trench quarry with vertical faces about one km to the west**,** on the opposite side of the mountain.

Sources: This is one of the few quarry exploitations in southern Spain incorporated in an official hiking itinerary and benefits from an explanatory panel.

Toponymy: The name *Lachar* signifies a quarry where l*anchas* (large, naturally flat slabs) are extracted. The name is appropriate for this specific millstone production.

The quarry: The site comprises two separate parallel trenches several metres deep. The longer trench (A), to the north, measures about 300 m, while the second (B) is about 50 meters long. Both exploit a specific homogeneous layer of massive limestone. Working debris was accumulated in cordons along each side of the trench.

Techniques: Blocks were split from the rock layer, probably with wedges, before being fashioned into cylinders.

Products and quantification: The dozen unfinished or broken millstones strewn about the site measure between 1,00 and 1,30 m in diameter. Upper stones are cylindrical. Lower stones present a flat base and a slightly convex grinding surface.

Transport and distribution: In the western sector of the quarry several walls are backfilled with debris. These features could have served as pathways to descend into the trench and slipways to facilitate the exit of the cylinders. About 100 m from the quarry there is path that follows its southern edge. This was probably the road used to descend with the products to the town of Jimena. From the number extractions the site certainly provided stones to more than to the local watermills.

Dating: From the sizes of the cylinders and the "whiteness" of the rock, the site appears to date to the Modern or Contemporary period.

Dwelling: Several "*caracolas*" can be seen in both the quarry and in the surrounding area. *Caracolas* (literally "snails") are very small (2-4 m2), most often, circular drystone wall hovels. The features are temporary dwelling often known to have been used by livestock herders (López & González 2005: 68). Several were built with quarry debris inside the trench. Judging from their position, we can assume that they were built by the quarrymen and served them provisional shelters during the periods they were making millstones.

Rock type: White limestone and calcarenite (Geological map 927, Baeza, 1987; Geological map 948, Torres, 1988). From our observations, the rock exploited is a white limestone.

View from the west of the one of the sectors of trench A.

Views of the western, shallower, sector of Trench B.

Views of the deep eastern sector of Trench A.

Detail of the massive, homogeneous layer exploited for millstones (Trench A).

View of the rock layer exploited for millstones.

Different views of a detached, roughly rectangular block along the edge of Trench A. The block was first split (probably with wedges) before being fashioned with a pick (parallel tool marks) into a rough cylindrical shape.

Examples of abandoned millstones measuring between 1,00 and 1,30 m in diameter.

Detail of a slightly convex lower stone measuring about 1,15 m in diameter.

View of two cylindrical upper stones beside a hovel.

Detail of an upper stone beside the hovel.

Views of the western sector of Trench A.

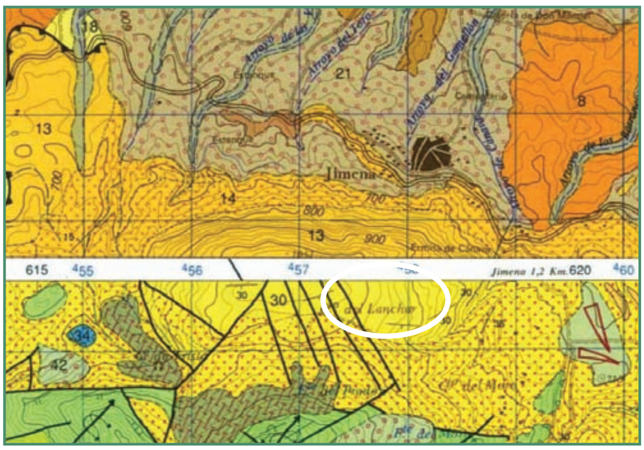
*Detail of a "*caracol*" (hovel) beside the quarry trench in the western sector.*

View of a retaining wall in the western sector of Trench A that served as access to the trench's lower level of the.

Explanatory panel at the Lachar millstone quarry.

Con la denominación de chozos, caracoles, monos o cuevas se designan en las poblaciones de la comarca de Sierra Mágina a las construcciones que forman un pequeño habitáculo de falsa bóveda, con muros y cobertura de piedra caliza sin labrar y sin ningún tipo de argamasa. Los hay de diferentes altura y planta, desde el que escasamente cabe un cuerpo a gachas para entrar, hasta los que presentan una puerta de entrada, que suelen ser más excepcionales. Se encuentran dispersos por el entorno rural de la sierra. ***Estos refugios recuerdan un pasado ganadero, aunque más tarde hayan sido utilizados y construidos también por canteros como habitáculo de los peones en el lugar de trabajo (canteras de piedra de Jimena*** *o del Mercadillo en Pegalajar), y por agricultores cuando los cultivos se extendieron por la sierra. Son en Sierra Mágina muy abundantes. Los materiales utilizados se encuentran alrededor de la obra y por la sencillez de su construcción, sin argamasas de unión, están plenamente integrados en el paisaje.*

(from López Cordero 2005: 68)



Montage of extracts from the geological maps 927 and 949 (IGME). The quarry is located in a unit of white limestone and calcarenite (yellow).

Sources

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J-3 Huelma-Solera

Las Canteras

Latitude: 31º 39′ 24.67″ N
Longitude: 3º 24′ 16.04″ W
Altitude: c. 1155 m

View of the Las Canteras mountain from the northwest.

Orthophoto of the Cerro de la Cantera (SIGPAC).

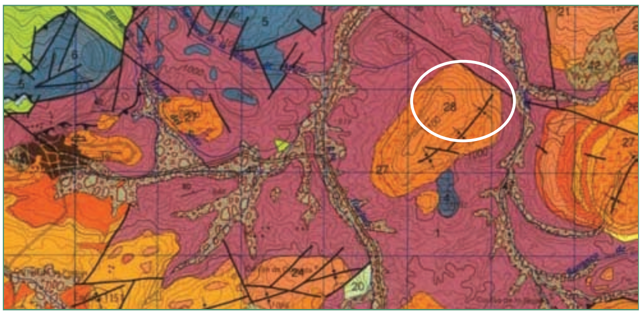
Location: *Las Canteras* is at the Cerro de la Cantera Mountain 4 km to the east of Huelma, along the southern edge of the Sierra Mágina Mountains. The sites, unfortunately, was not possible to access during our visit.

Source: The geographer Madoz records that both millstones and other (unspecified) products were manufactured at the place name *Canteras* (Madoz 1947, Vol. 9: 260).

Toponymy: The place-name *Canteras* (quarries) on the geographical map is clearly indicative of stone work. In the cadastre, however, place name *Canteras* does not appear. In its place is *Campo Moral*, which, after inverting the consonants "r" and "l" is *Molar*, a toponym at times associated with millstone workings.

Dating: Middle of the 19th century.

Rock type: Bioclastic sandstone (Geological map 970, Huelma, 1988).



Extract from geological map 970 (IGME). The quarry is located in a unit of bioclastic sandstone (orange).

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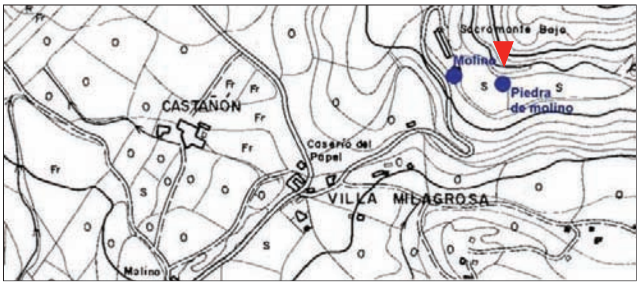
J-4 Cambil

Arbuniel - Los Batanes

Latitude: 37º 38' 4,26" N
Longitude: 3º 31' 38,43" W
Altitude: c. 830 m

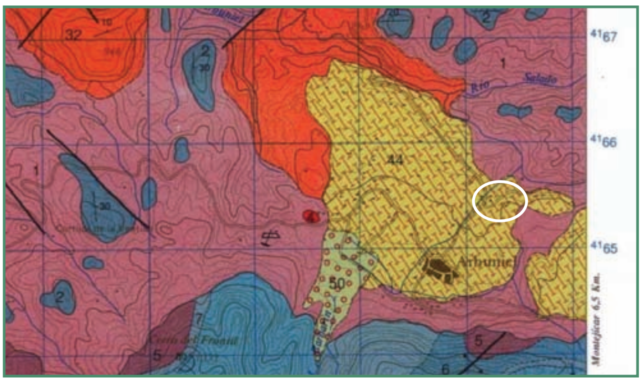


Map of the position of the quarry (from López & Cabrera 2004).

Location: This small millstone exploitation, about one km northeast of Arbuniel, is at the foot of the Cerro Vilches Mountain near an old fulling mill (*Molino de los Batanes*) on the Arroyo del Muerto stream. The site was, unfortunately, not accessible during our visit.

Source: The site is cited in a general study of the cultural heritage of the town of Arbuniel (López & Cabrera 2004: 209-210).

The quarry: The quarry comprises what appears to be a single abandoned millstone carved into a large block, probably detached from a nearby crag. We ignore the reason the millstone was abandoned.



Extract from geological map 969 (IGME). The block is associated with a unit of limestone tuffa or travertine.

Product and quantification: The single millstone measures approximately 1,50 m in diameter and 44 cm thick.

Transport and distribution: This millstone was probably destined for a nearby watermill.

Dating: Based on the size of the cylinder, the site could date anywhere from the Medieval to Contemporary times.

Rock type: Limestone tufa or travertine (Geological map 969, Valdepeñas de Jaén, 1988).

Views of the quarry (from López & Cabrera 2004).

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J-5 Andújar

Los Morales

Latitude: 38º 6’ 24.50 N
Longitude: 4º 1’ 17.43 W
Altitude: c. 669 m

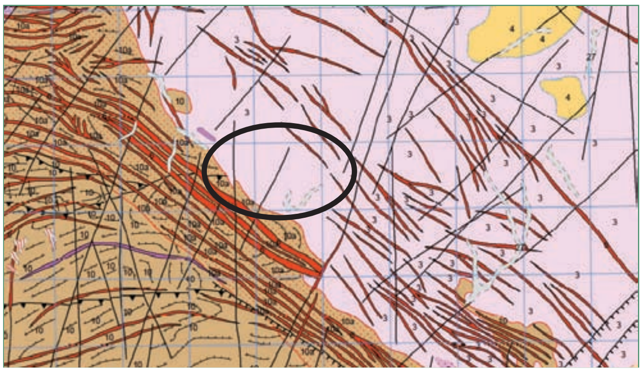
Location: The only *Morales* place name we have identified in the Municipality of Andújar is the *Peñascal de Morales,* a mountain about 6 km north of the city of Andújar.

Source: Millstone exploitation is cited in passing by Madoz who wrote that although there are “innumerable” granite quarries” in the area for both “*molinos de pan y de aceite*” (flour and oil mills), the only quarries open at that moment were those of *Morales* and *Pedroso* (see J-6) (Madoz 1845, Vol. 2: 305).

Toponymy: The place name *Morales* (mulberries) could derive from *Molares* (millstone quarry) after inversion of the consonants “r” and “l” (typical in spoken Andalusian). A few hundred metres to the northeast is a *cortijo* with the name *Villa Molero* (*molero* meaning millstone maker). This toponym reinforces the presence of an old millstone quarry in the surroundings.

Dating: The Madoz references places the site in the mid-nineteenth century.

Rock type: Porphyric biotite granite (Geological map 904, Andújar, 1992). The position of the Peñascal Mountain on the geological map 904 (*IGME*) coincides with this rock unit and with the description of Madoz.



Extract from Geological map 904 (IGME). Peñascal mountain is on the southern border of a vast unit of porphyric biotite granite (light purple) beside a large unit of slates and greywackes (light brown).

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MADOZ, Pascual. *Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar*, Madrid, Vol. 2. 1845.

J-6 Andújar

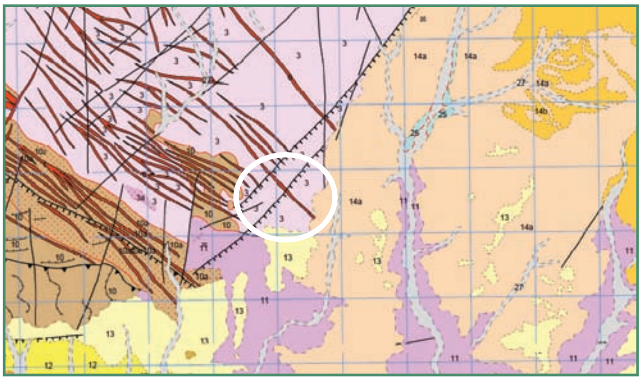
El Pedroso

Latitude: 38º 5′ 35.81″ N
Longitude: 3º 57′ 12.48″ W
Altitude: c. 330-340 m

View from the southeast of the Pedroso area (extract from Google Maps Street View).

Location and toponymy: *El Pedroso* is a place name 10 km northeast of the city of Andújar at the foot of the Cerro de los Zumacares. Two recent quarries are indicated in this area, notably one at la Dehesilla. The exact location of the of millstone quarry, however, is unknown. In any case, the name *Pedroso* means terrain with many rocks.

Source and products: Madoz states that although there are "inumerable" granite exploitations in the area for both "*molinos de pan y de aceite*" (flour and oil mills), the only in use at the time were *Morales* (see J-5) and *Pedroso* (Madoz 1845, Vol. 2: 305).



Extract from Geological map 904 (IGME). The Pedroso toponym coincides with a unit of porphyric biotite granite, the presumed location of the quarry (light purple) and a unit of siliceous conglomerates and calcarenites (beige).

Dating: The Madoz references place the site in the mid-nineteenth century.

Rock type: Porphyric biotite granite (Geological map 904, Andújar, 1992). The position of the Pedroso toponym on the geological map 904 (*IGME*) coincides with this type of rock and with the description or the rock by Madoz.

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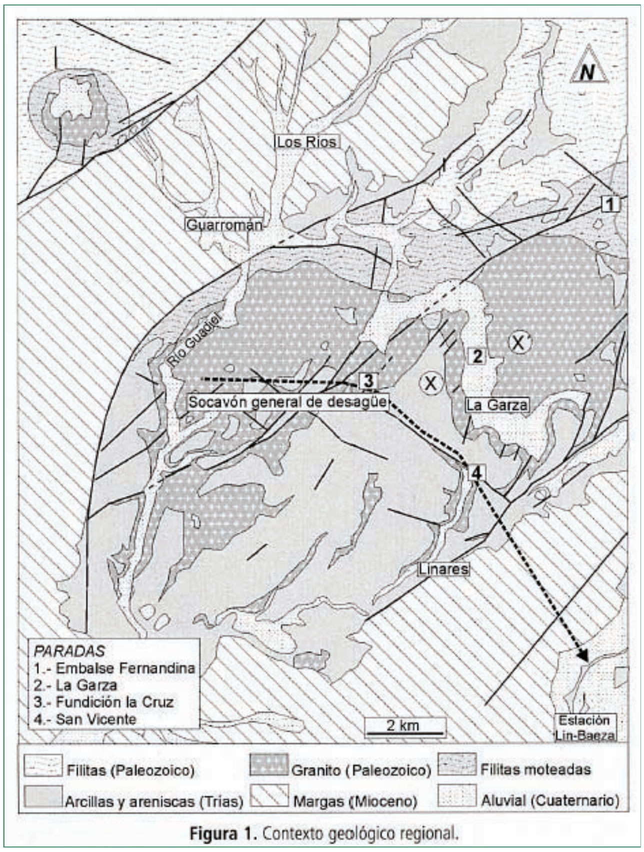
J-7 Linares district

Location and sources: In a 19th-century description of the mining products of the Province of Jaén, millstone and olive oil roller quarries are identified in the granite districts near the city of Linares by both Madoz (1847, Vol. 10: 290) and Lozano Muñoz (1867: 17). There are, in fact, two large granite units to the north of Linares in an area between Linares, Guarromán to the northwest and Vilches to the northeast where either granite surface blocks or bedrock could have been exploited. None of these quarries, however, have been identified in the field.

Dating: Madoz place millstone working in this district in the middle 19th century. There was certainly an older tradition in the area.

Rock type: Granite.



Map of the two vast granite units in the region north of Linares. Geological map, Jaén (Hidalgo Estévez et al. *2002: 310, fig. 1).*

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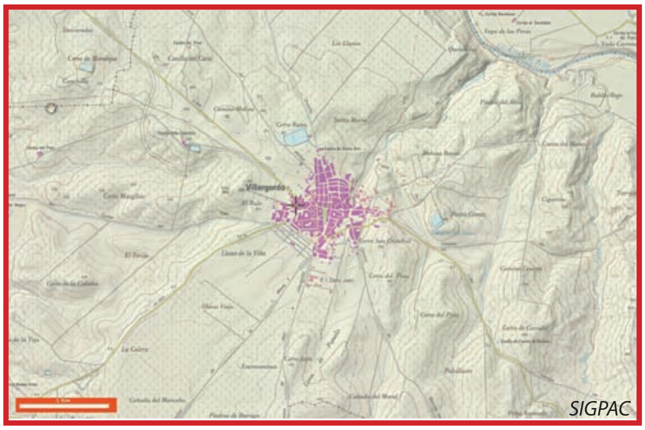
J-8 Villatorres

Villargordo

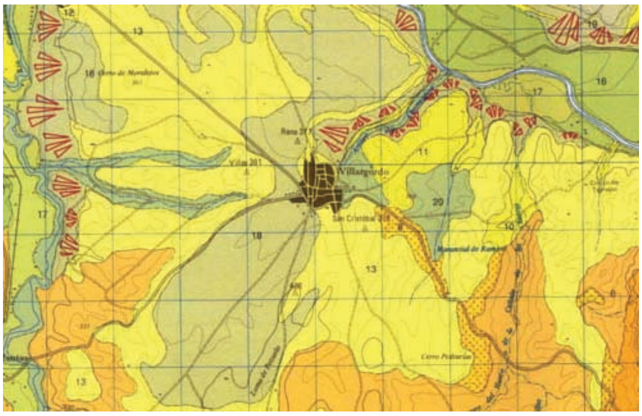


Location: Villargordo is a town in the Villatorres Municipality about 20 km north of the city of Jaén. The exact location of its millstone quarry is not known.

Source, transport and distribution: This site is identified in a notarial protocol in the Archives of the Province of Jaén (1499.11.26, AHPJ, PNJa, 9, 415r) published by Córdoba de la Llave (2003: 306, footnote 26). The protocol records that Pedro Martínez (either a stone cutter or a cart driver) should deliver 8 days before Christmas a lower stone measuring 7 *palmos* in diameter (about 1,47 m) and 2 *palmos* in thickness (about 42 cm) to Diego Fernández de Ulloa, for the Molino Nuevo (presumbly in the city of-Jaén) from the *molar* (quarry) of Villargordo.

Dating: Late Medieval - Early Modern.

Rock type: Based on the geological map, the most likely source is yellow unit 13, a conglomerate. The other surrounding units (clays, alluvial deposits) do not correspond to millstone production (Geological map 926, IGME, Mengibar, 1987).



Extract from Geological map 926 (IGME). Conglomerate (unit 13, in yellow) appears to be the only rock suitable for millstone production in the vicinity of Villargordo.

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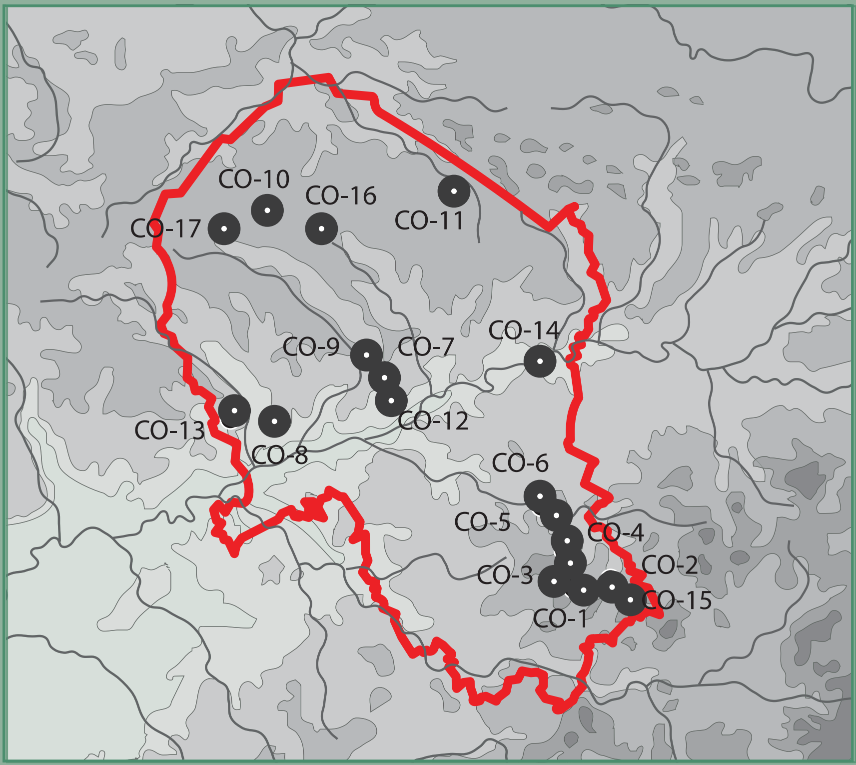
ANDALUSIA

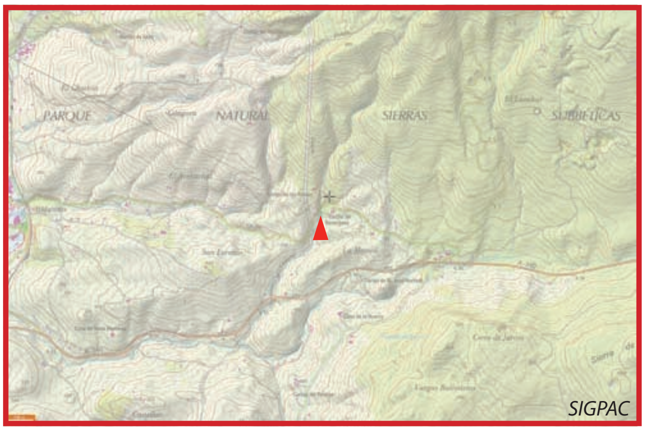
CÓRDOBA (CO)



CO-1 Cabra

Cantera de los Frailes

Latitude: 37° 28′ 3.10″ N
Longitude: 4° 23′ 30.33″ W
Altitude: 685-700 m



View from the south of part of the millstone quarry of Cantera de los Frailes, Cabra. The vertical "baulk" is possibly a marker of the limit between concessions to different teams of millstone makers.

Location and generalities: The *Cantera de los Frailes* is one of the largest (15000 m2) millstone exploitations in southern Spain and one of the most spectacular. It is located along the Frailes Stream in the National Park of the Subbetic Sierras, 5 km east of the town of Cabra.

Sources: The geologist Ezquerra del Bayo refers the site in two different publications in the middle of the 19th century, due largely to the presence of fossils (ammonites). The first reference dates to 1847,

Extract from the cadastre (SEC) with the place name Cantera de los Frailes *(quarry of the Friars).*

and identifies an important millstone production "a league east of Cabra" (Montero 2008: 168), a distance that coincides perfectly with the site. The same geologist about 10 years later, refers once again to "a vast and long established millstone exploitation that supplies millstones throughout the region" (Ezquerra del Bayo 1856: 384-385). It is astonishing that there is no mention of this site in the contemporary geographical dictionary of Madoz.

The main source of information about this site, however, is a recent article about watermills in the city of Córdoba (Montero 2008), published in the proceedings of a molinological colloquium.

Toponymy: The name *Los Frailes* (the Friars) derives from the *cortijo* (farmhouse) uphill from the site and is possibly related to the Hermitage of Our Lady of the Sierra at the peak of the mountain. It is not clear if the name is indicative of ownership of the quarry by members of the clergy.

The quarry: The site is a classic example of a bench quarry cutting into the side of a hill, with cylinders hewn directly from bedrock in a true extractive manner resulting in multiple vertical tubular hollows.

A unique feature is the series of square "compartments" that can be clearly identified from the aerial views. These could be indicative of the boundaries of the different concessions.

There is also high towering vertical "baulk" in the middle of the extraction area, a feature that is known in other quarries (especially construction quarries), for example at Sisapo (CR-1) or the celebrated site of El Mèdol in Tarragona. This feature, probably also a limit between production concessions, could be interpreted as a display case for potential customers to observe the strata of the rock.

Techniques: The quarry faces are covered with multiples diagonal lines resulting from cutting circular trenches with picks. Quarry floors are not visible, hence splitting techniques cannot be determined.

Product and quantification: The site shows hundreds of extractions. Although some are quite big (1,40 m diameter), most are about 1,00 m in diameter. Contrary to the nearby site of the Cortaores (CO-2), which also served as a block quarry, extraction here is strictly for millstones.

View of a group of abandoned millstones at the "entrance" of the quarry.

Transport and distribution: The site is cut in two parts by an old road. Along this road is a group of millstones waiting to be loaded for transport. It is, however, not certain if this is the original loading zone or if the stones have been gathered by pillagers long after the abandonment of production.

Ezquerra del Bayo (1856: 385) comments that the millstones from Cabra are commercialised throughout the region and even reached the city of Málaga 85 km to the south (as the crow flies). Petrographical research has shown that products of this quarry reached watermills of the city of Córdoba, 60 kilometres to the northwest (Montero 2008).

Dating: In spite of evidence of Roman extraction of construction material in the region, in particular at Los Cortaores (Padilla 1999: 276) (see CO-2), there is no evidence of Roman quern or millstone workings. The work of the geologist Ezquerra del Bayo places the production in the middle of the 19th century. It is reasonable to assume that the production is even older, at least until the beginning of the 19th century, based on Ezquerra's statement that the quarry was already a long-established production centre.

The passing reference to a "*Cabreña*" (meaning "from Cabra") millstone at the watermill in Aguilar de la Frontera (25 km away) in a 1904 notarial protocol (Córdoba de la Llave & Varela 2011: 335) places production as late as the early 20th century. This could coincide with several larger millstones model about 1,40 m in diameter.

Rock type: In the early 19th century literature the rock is defined respectively as a sandstone, breccia and limestone. It is in fact a pinkish nodular limestone (*Rosso Ammonitico* facies) (Geological map 989, Lucena, 1988).

View of a quarry face in the northwestern sector with high, tubular extraction hollows bearing multiple diagonal pick marks.

View from the northeast of the southwestern area of the quarry with the "baulk" and the road that leads to Cabra.

Detail of the southwestern area of the quarry and the road.

View of the northwestern quarry face and the "baulk" (to the right).

Detail of the northwestern quarry face.

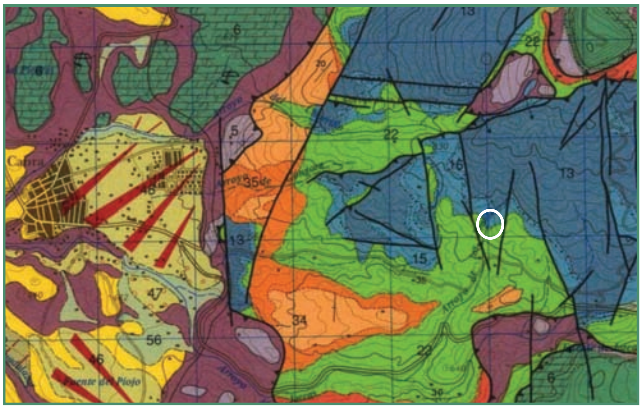
Views of the southeastern sector of the quarry.

Views of the compartments along the eastern edge of the quarry. These could correspond to concessions.

View of a group of abandoned millstones along the eastern quarry face. This group, along the road, may have been ready to be hoisted on carts for transport.

Views of abandoned millstones. Although most of the cylinders are about 1 m in diameter, there are a few larger examples.

Orthophotos of the Frailes quarry (SIGPAC). A modern exploitation is seen on the upper right side of the general view. The quarry boundaries, concessions (?) of the different working areas, are clearly visible on the detail to the right.



Extract from geological map 989 (IGME). The blue with dots represents a characteristic pink limestone with ammonites.

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PADILLA MONJE, Aurelio. Consideraciones en Torno a la Explotación del Mármol en la Bética Durante los Siglos I-II. *Habis*, 30. 1999, p. 271-281.

Acknowledgements

I thank Rafael CARMONA, director of the Municipal Museo de Priego de Córdoba, for leading me to this site.

CO-2 Cabra

Los Cortaores

Latitude: 37° 27′ 48.95″ N
Longitude: 4° 22′ 38.03″ W
Altitude: 720 m

General view of the quarry from the southwest.

Orthophoto of the northern sector of the site (SIGPAC).

Location and generalities: The site, known as *Los Cortaores* ("cutters"), is about 1 km to the east of the *Cantera de los Frailes* (see CO-1) on both sides of the main road linking Cabra to Carcabuey. On the cadastre (SEC) the area is called *Lanchar*, meaning the quarry where "*lanchas*" (slabs) are extracted. A very large modern rock exploitation is about 1 km northeast of the old quarry site.

Sources: The site is mentioned in the studies by Padilla Monge (1999) and Montero (2008).

The quarry: The site is an extended, shallow surface quarry where the products were scored directly from the bedrock.

Products and quantification: Millstone production is modest at the site. There are a few extraction hollows and abandoned cylinders measuring about 1, 00 m in diameter. This site is far from the production of the Cantera de los Frailes (CO-1), about 1 km to the west. In Roman times, blocks were extracted for sculpture, architecture and for epigraphic inscriptions (Padilla Monje 1999: 276). An example bearing an inscription is exposed in the Municipal Museum of Priego de Córdoba.

Transport and distribution: This site benefited from the adjacent road. Products from here were certainly local. This distribution of this product would be eclipsed or insignificant compared to that of the nearby Los Frailes (CO-1) quarry.

Dating: The millstone production could date from Medieval to Contemporary times. Block extraction is Roman.

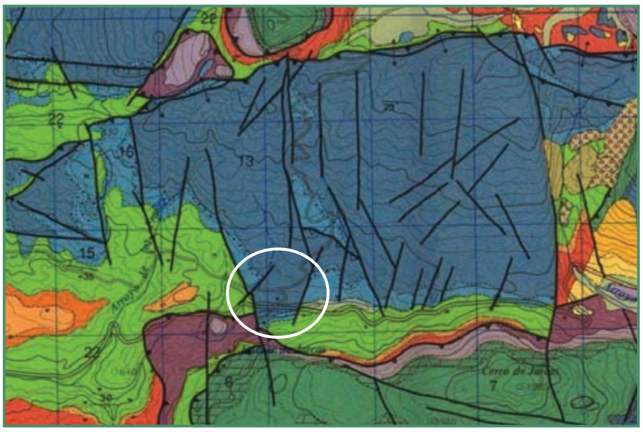
Rock type: Pinkish nodular limestone (*Rosso Ammonitico* facies) (Geological map 989, Lucena, 1988) (see CO-1).

View of one of the quarry areas in the northern sector. The abandoned square block on the left is Roman.

Detail of an abandoned roughout in the northern sector of the quarry.

Detail of a low cylindrical millstone extraction in the southern sector (to the south of the road).

Detail of an abandoned high, slightly trunco-conical, cylinder extraction in the southern sector. This extraction was certainly destined as a roller, probably for the oil industry.



Extract from geological map 989 (IGME). The blue with dots represents a pink limestone unit with ammonites.

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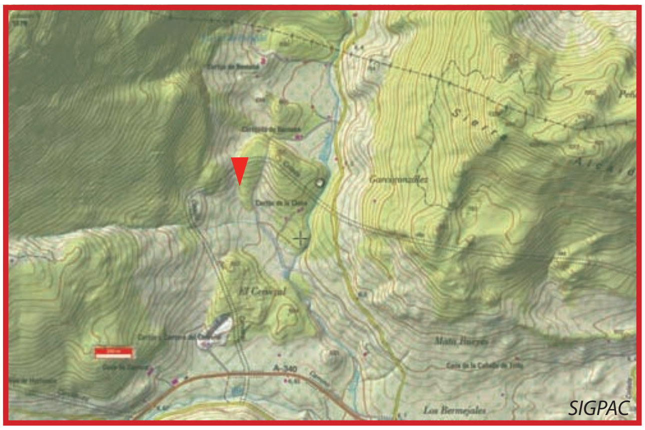
Acknowledgements

I thank Rafael CARMONA, director of the Municipal Museo of Priego de Córdoba, for guiding me to the site.

CO-3 Carcabuey

Cudillas

Latitude: 37º 28' 47.98" N
Longitude: 4º 18' 0.84" W
Altitude: 620 m



General view of the quarry from the south.

Location: The millstone quarry of *Cudillas* is about 4 km northwest of the town of Carcabuey at the foot of the Lobatejo mountain.

Sources. This site is not mentioned in any known written source.

The quarry: The quarry face is about 40 m long and between 3-4 m high. The upper layers are extremely brittle (overburden) and were not exploited. Millstones were scored from a specific compact layer of rock about 80 cm thick at the base of the quarry face that distinguishes itself from the upper strata by a different, less weathered, patina.

Techniques: The absence of tool marks and circular hollows along the quarry face suggests that the quarrymen detached angular blocks with levers before fashioning. Fashioning took place opposite the quarry face as seen by a number of abandoned cylinders in different stages of manufacture.

Wedge holes are visible on some of the larger blocks among the debris. These holes suggest that unwanted material was cut away by wedging before the stone was fashioned.

It is of note that in the immediate area, in a radius of a few hundred metres, there are several abandoned millstones in an advanced state of manufacture. They probably are indicative of the exploitation of other smaller outcrops or surface blocks in the area.

Production and quantification: The millstones manufactured at this site measure about 1,10-1,20 m in diameter. Based on the length of the rock layer (40 m), and considering that two millstones could be hewn from a thickness of 80 cm, production must have been around 50 millstones.

Transport and distribution: The present dirt road that leads to the quarry is probably the same that was used in the past to transport the millstones. Based on the reduced number, production was limited to the local sphere.

Dating: There are no direct references to this quarry among the old texts. From the size of the products, they could date from Medieval to Contemporary times.

Rock type: Limestone (Geological map 989, Lucena, 2988).

View of the quarry face and working debris. The quarrymen exploited a homogenous layer at the base of the quarry face.

View from the southwest of the quarry face and working debris.

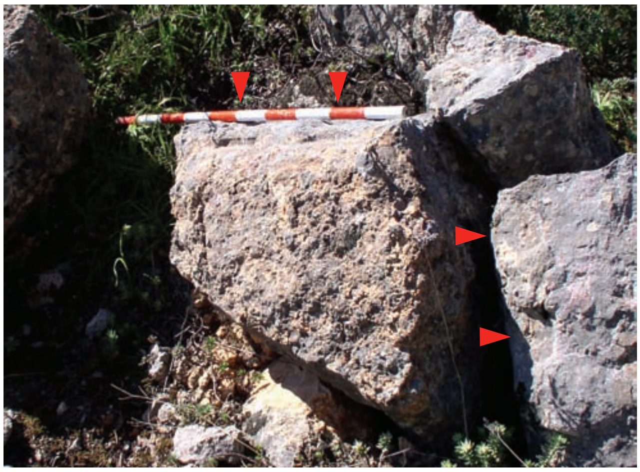
Detail of the stratum exploited for millstones.

Detail of an abandoned cylinder.

Detail of a broken millstone.

Detail of an abandoned cylinder.

Examples of abandoned and aborted millstones among the debris contiguous to the quarry.



Examples of wedge holes for rock splitting on working debris.

Examples of abandoned and millstones in the fields near the quarry.

Extract from geological map 989. The green and blue units correspond to different facies of limestone.

Bibliography

PADILLA MONJE, Aurelio. Consideraciones en Torno a la Explotación del Mármol en la Bética Durante los Siglos I-II. *Habis*, 30. 1999, p. 271-281.

Acknowledgements

I thank Rafael CARMONA, director of the Municipal Museo of Priego de Córdoba, for information about this site.

CO-4 Priego de Córdoba

Vega de los Morales

Latitude: 37º 30’ 41.39” N
Longitude: 4º 10’ 58.02” W
Altitude: c. 470 m

View of the millstone quarry of Vega de los Morales (photograph by Rafael Carmona).

Location: The site along the northern border of the Municipality of Priego de Córdoba near the place name *Vega de los Morales* (bordering the Municipality of Luque).

Toponymy: The place name *Morales*, meaning “mulberry” is possibly an inversion of the syllables “r” and “l” (typical in spoken Andalusian) of “*Molares*”, the toponym par excellence of millstone quarries.

The quarry: The exploitation is very modest, consisting, to our knowledge, of only two aborted cylinders carved directly into a small outcrop protruding from the a slope.

Product and quantification: The larger, truncoconical cylinder is possibly an unfinished oil roller. The second extraction, a low cylinder, probably corresponds to a millstone.

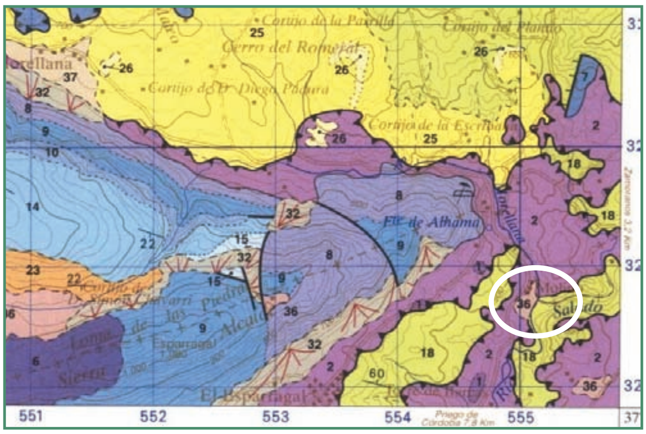
Transport and distribution: Production was local.

Dating: The diameters of the millstones, approximately 1 m, is compatible with a Medieval to Contemporary date.

Rock type: Probably a displaced block detached from an uphill sandstone outcrop (Geological map 967, Baena, 1985).

Details of the abandoned cylinders (photograph by Rafael Carmona).

Details of the abandoned cylinders (photograph by Rafael Carmona).



Extract from geological map 967. The area of the quarry corresponds to the beige (no. 36), a unit of landslide zones probably originating from sandstone outcrops (purple).

Acknowledgements

I thank Rafael CARMONA, director of the Municipal Museo of Priego de Córdoba, for the information about this site.

CO-5 Baena

Molino de la Piedra

Latitude: 37º 35′ 56.00″ N
Longitude: 4º 18′ 58.74″ W
Altitude: 405 m

View from the north of the Marbella River Valley and the Molino de la Piedra beside the boulder (extract from Google Maps Street View).

Satellite view of the quarry beside the watermill Molino de la Piedra (extract from Google Maps Satellite View).

Location: The millstone quarry of the Molino de la Piedra (or Peña) is 2 km south of the town of Baena at a bend along the Marbella River.

Source: It is cited briefly in a recent study of hydraulic mills at the flour mill called the Molino de la Peña, along the Guadajoz Valley (Córdoba de la Llave & Varelo 2012: 101-102).

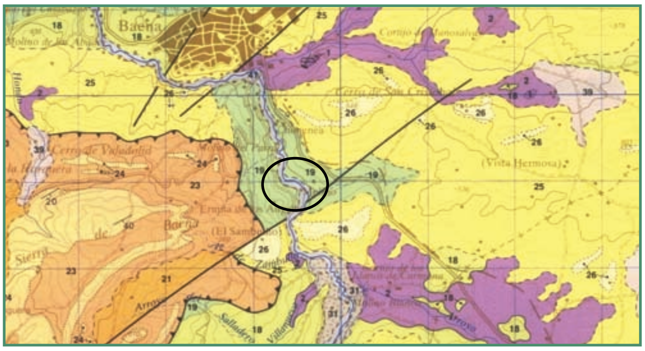
Toponymy: The name "*Piedra*" meaning rock, refers to a huge boulder (*peña*) a few steps away from the *Molino* (watermill).

The quarry: The top of this boulder bears extractions of construction material, as well as a few millstone hollows probably destined to the neighbouring watermill.

Dating: The Molino de la Piedra is dated to the 19th and 20th centuries. The older version of installation, called the Molino de la Peña (Peña meaning rock or crag) is dated by a notarial protocol dating to 1557 (Córdoba de la Llave & Varelo 2012: 25). The date of millstone extraction falls, presumably, between these two dates.

Rock type: The source of this displaced block is not known. It could be a bioclastic limestone (yellow) or sandstone (orange) (Geological map 967, Baena, 1985).

The millstone quarry is located on the boulder to the right of the watermill Molino de la Piedra (from Córdoba de la Llave & Varelo 2012: 99).



Geological map 967 (IGME). The source of the displaced boulder could be either the limestone (yellow) or sandstone (orange) unit.

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CO-6 Baena

Monte de Iscar (Izcar)

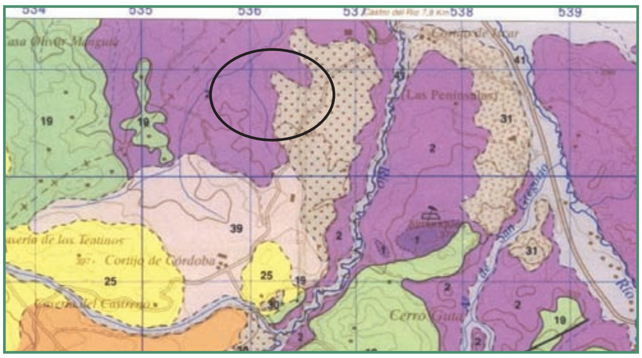
Location and toponymy: The *Monte de Iscar* (now spelled *Izcar*) is about 6 km northwest of Baena. The place name is shared with the neighbouring Municipality of Castro del Río. The precise location of the quarry is not known. It is possibly at the site of the present Municipal Waste Processing Centre. The name *Iscar* is without a doubt a diminutive of the name Lentiscar designating a type of shrub.

Source: The Izcar quarry is related directly to the Molino de la Piedra, a watermill located south of the city of Baena (see CO-5). A notarial protocol dating to 1557, conserved in the Archives of the city of Córdoba convened that Miguel Ruiz de Lucena, a quarryman and resident of Baena, deliver to Andrés López, also from Baena, two millstones measuring "*seis cuartas y media en ancho y dos de alto*" (i.e. a diameter of 1,40 m and a width of 42 cm) (Córdoba de la Llave & Varelo 2012: 106). The protocol specifies that the stones be extracted from the quarry of *Iscar* and must be ready on the day of St. John (28th of June).

Dating: 16th century.

Transport and distribution: The distance of the Izcar Mountain to the Molino de la Piedra is between 8 and 9 kilometres following the road along the Guadajoz and Marbella River Valleys.

Rock type: Unknown. According to the Geological map 967, Baena, 1985, there are sandstones and conglomerates at Izcar.



Geological map 967 (IGME). The precise location of the quarry is unknown. It could have exploited either a unit of sandstone (purple) or conglomerate (dotted beige).

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CO-7 Córdoba

Santa Ana de Albaida

Latitude: 37° 54' 18.48" N
Longitude: 4° 40' 43.47" W
Altitude: c. 400-420 m

View of one of the sectors of the Santa Ana de Albaida quarry (photograph by Francisco Madrigal, Canteras de Santa Ana de la Albaida, Blog, http://pacomadrigal-cordoba.blogspot.com.es/2012/07/canteras-de-santa-ana-de-la-albaida.html).

Location and generalities: The quarry complex of Santa Ana de Albaida is 4 km northwest of Córdoba at the foot of the Sierra de Córdoba. These vast exploitations, covering a surface of almost 100,000 m2, are divided into both open-air pits and subterranean galleries. They furnished the city of Córdoba for centuries with construction material (Penco Valenzuela, *et al.* 2004). The exact location of the millstone production at the site is unknown.

Source: Millstone production is corroborated by a notarial protocol dating to 1486 (Córdoba de la Llave 1988: 843, footnote 23; 2003: 306, footnote 26). Montero, echoing Córdoba de la Llave, states that Albaida was the source of millstones for the city of Córdoba before the arrival of the *rosso ammonitico* from Cabra (see C0-1) (Montero 2008).

Production and quantification: The protocol details that the millstone should be scored at Albaida, be in two pieces, and measure "*ocho palmos*" (1,60 m) in diameter. This is one of the few historical written sources (1486) identifying a centre producing millstone segments. We ignore the volume of production of the site. In any case, it could have been great considering the number of watermills in the city of Córdoba. It is worth noting that this quarry is reputed to have produced only lower stones (Córdoba de la Llave 2003: 305).

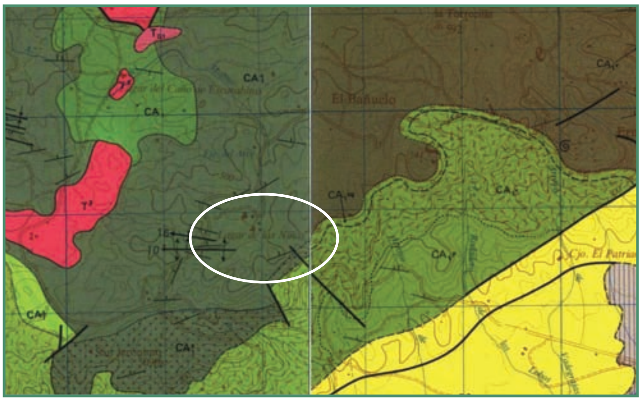
Transport and distribution: The millstone production certainly benefited from the transportation network established for construction material for the city of Córdoba. It would have taken a cart less than a day to cover the few kilometres to the city. We ignore the volume of millstone production and, if production was great, if the city of Córdoba was used as a springboard for export to other regions.

Dating: Late 15th century (Late Medieval to Early Modern.

Rock type: Dolomite rocks and limestones (Geological map 922, Santa María de Trassierra, 1972; Geological map 923, Córdoba, 1973). Calcarenite sandstone (according to Penco Valenzuela, *et al*. 2004: 233).

View of the Albaida quarry faces (photograph by Jose Manuel Borja, www.eltiempo.es).

View of the Albaida quarry faces (photograph by Jose Manuel Borja, www.eltiempo.es).



Montage of geological maps 922 and 923 (IGME). The quarries of Albadia are in a unit of limestone and dolomite (hews of green).

Sources

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CO-8 Posadas

Cantera Honda

Latitude: 37° 49′ 21.25″ N
Longitude: 5° 9′ 15.19″ W
Altitude: c. 220 m

View of the Cantera Honda quarry (photograph by Vértice Córboba, http://www.flickr.com).

View of abandoned cylinders at the Cantera Honda quarry (photograph by Vértice Córboba, http://www.flickr.com).

Location: The site of *Cantera Honda* (deep quarry) is near Los Rubios de Paterna, about 5 km northwest of Posadas.

Source: The site is recorded briefly in an archaeological study of Roman amphorae in which the author notes the presence of abandoned "drums" in the quarry and suggests they are roughouts for millstones (Berni Millet 2008: 459).

It is probably more reasonable, based on the monumental nature of the site and the diameter of the extractions (around 1 m), that the drums were in fact Roman column segments. This site is retained in this study, nonetheless, because the cylinders, like those of Cerro Bellido in the Province of Seville (SE-4), could have been recycled into millstones. In any case, the rock (limestone or dolomite) is perfectly compatible with that of millstone exploitation.

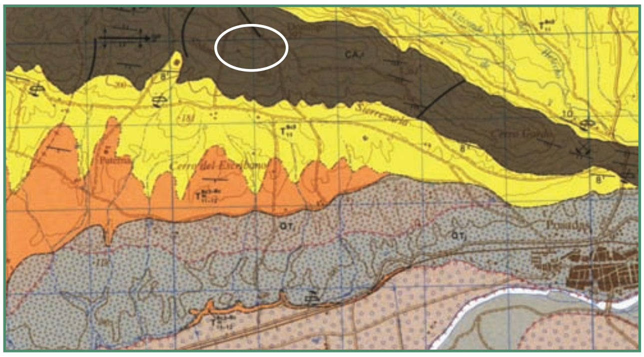
The quarry and extraction techniques: From the photographs, it is obvious that the cylinders were hewn directly from the quarry face through true extraction, leaving high tubular hollows.

Dating: Roman, possibly later (Medieval?).

Rock type: Limestones or dolomites (Geological map 943, Posadas, 1973).

View of the Cantera Honda quarry face with high, vertical tubular hollows, probably for column drums (photograph by Vértice Córboba, http://www.flickr.com).

View of the Cantera Honda quarry face with an abandoned drum still in place (photograph by Vértice Córboba, http://www.flickr.com).



Extract from geological map 943 (IGME). The quarry is in the unit of dolomites and limestones (dark brown).

Source

Vertice photos: http://www.flickr.com/photos/vertice1/2561950036/in/photostream/[accessed November 12, 2012].

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CO-9 Córdoba

Los Arenales

Location: *Los Arenales* is about 6 kilometres north of the town of Santa María de la Trassierra on the northern border of the Córdoba Municipality. The site is marked by a bridge crossing the Guadiato River. The exact location of the quarry is not known.

Source: Madoz, in his description of the town of Santa María de la Trassiera, records a millstone quarry at Los *Arenales* (849, Vol. 15: 136). The author, unfortunately, provides not other information about the site.

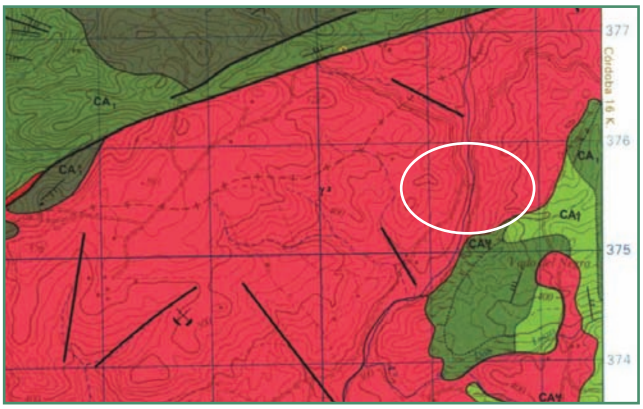
Toponymy: *Los Arenales* means a large sandy area. The name is compatible with a sandstone outcrop.

Production and quantification: We ignore the number of millstones produced at this site.

Transport and distribution: The site is along a main road linking the cities of Córdoba and Villaviciosa de Córdoba.

Dating: Middle of the 19th century.

Rock type: Sandstone or conglomerate (Geological map 922, Santa María de la Trassierra, 1972).



Extract from geological map 922 (IGME). The quarry is in the unit of sandstones and conglomerates (red).

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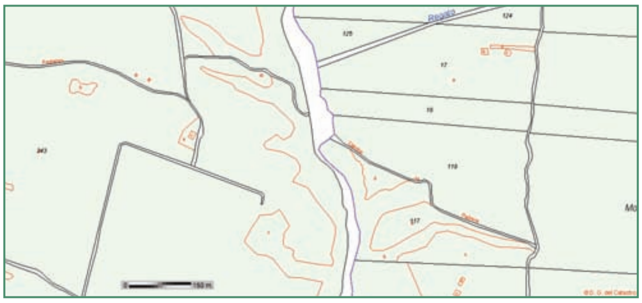
CO-10 Belmez

La Pedrera, Arroyo Albardado

View of the Albardado millstone quarry (photograph by Manu Elviar, http://www.flickr.com).



Extract from the cadastre of Belmez with the Camino de Pedrera *(Quarry Road) crossing the Albardado stream flowing N-S (SEC).*

Location: This site is along the bed of the *Albardado* Stream a few kilometres east of Belmez. The stream flows from north to south over a distance of about 7 km and then joins the Guadiato River.

Sources: The earliest references to this site, a series of notarial protocols dating to the early 17th century, were identified during research carried out by secondary students of a school at Pozoblanco and published in their school internet site. The research in the archives of Pozoblanco revolve around the stone mason Juan de Bargas.

The first reference to Bargas is a notarial contract from 1606 that states that Juan de Bargas and María de Moya [or Misas] acquired from Pedro Martín Cejudo, native of Hinojosa, a millstone extracted and made in the quarry of Belmez from the "*Alvarado*" stream.

The second document dating a decade later is a contract binding Juan de Bargas to fashion a millstone extracted from the quarry of Belmez (1616). It is interesting to note that the archives record that Juan de Bargas not only made millstones, but also extracted building blocks, notably for the chapel of the hermitage of Nuestra Señora de la Luna.

Madoz, two centuries later, cites the Albardado production twice. In his description of the Guadiato River, he records that the Albardado Stream is noteworthy for its millstone quarries (1847: Vol. 9: 39). In the description of the surroundings of Belmez, he specifies that *piedra basta* (coarse stone) was worked for millstones along the Albardado (1846, Vol. 4: 131).

The quarry: In the photographs can be seen many large extraction hollows organised on tiers.

Toponymy: The name *Camino de las Pedreras* (road of the quarries) leading from Bélmez to the *Albardado* is probably related to the millstone work.

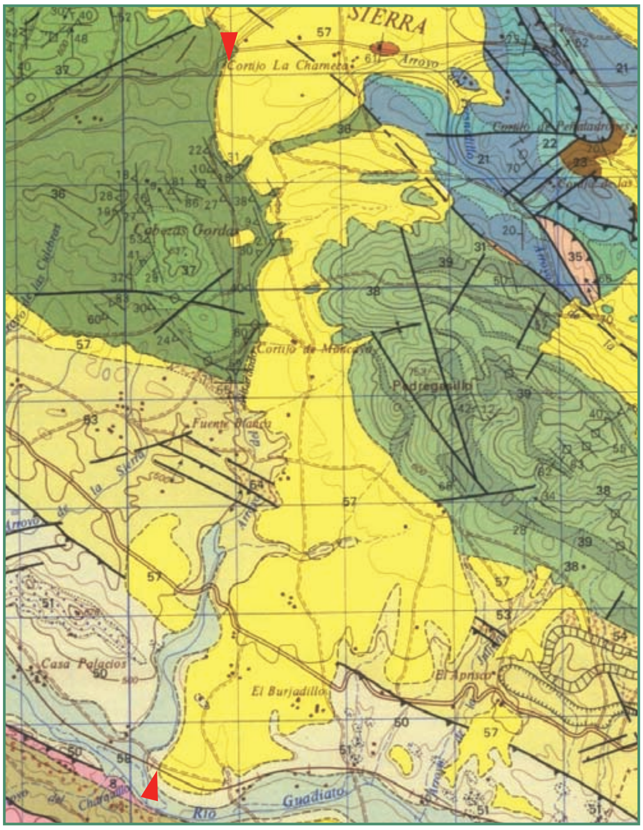
Production and quantification: 1606: The acquisition is that of a millstone measuring "*seis cuartas de vuelo y una tercia de grueso*" (about 1,20 m in diameter).

Transport and distribution: Madoz states that the quarry supplied the nearby towns, as well as other towns farther away (1846, Vol. 4: 131).

Detail of an extraction hollow (photograph from the website 30 Grados).

Dating: The notarial protocols place the quarry in the early 17th century. The references by Madoz show the site was still active in the middle half of the 19th century. Finally, in a recent article about hydraulic works in the Province of Córdoba, the Hernando Luna associates the quarry with recent watermills established along the Albardado Stream (Hernando Luna 1989: 275), suggesting it could have endured into the early 20th century.

Rock type: Conglomerate (Geological map 880, Espiel, 1982). This type of rock, with rounded quartzite clasts up to 10 cm in length, is confirmed by A. Dasa of the Escuela Politécnica de Minas of Bémez, and is compatible with the term "*piedra basta*" expressed by Madoz.



Extract from geological map 880 (IGME). The Albardado Valley runs north-south and is marked by units of conglomerates (both hews of yellow), the probable source of the quarries.

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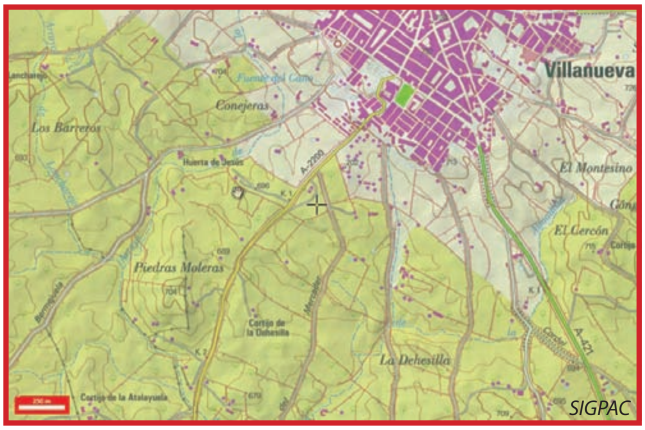
MADOZ, Pascual. *Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar*, Madrid, Vol. 9,1847.

CO-11 Villanueva de Córdoba

Piedras Moleras

Latitude: 38º 18' 31.45" N
Longitude: 4º 38' 39.83" W
Altitude: 670-700 m



View from the northeast of the Piedras Moleras *hill (extract from Google Maps Street View).*

Extract from the cadastre (SEC) showing the large area falling under the place name Piedras Moleras *and the precise location of the two sectors of the quarry.*

Location: The quarry is about 1,5 km southwest of the town of Villanueva de Córdoba on and around a hillock called *Piedras Moleras*.

Source and toponymy: The site is identified by its toponym. *Piedras Moleras* (millstone quarries stones) is an unequivocal indicator of millstone production. Although the existence of rock work at this site is confirmed orally by S. Gutiérrez, director of the Historical Museum of Villanueva de Córdoba, there is no evidence of millstone production.

The quarry: According to S. Gutiérrez, there are two extraction sectors. From the photographs it is possible to discern only block extractions. The quarry face of sector 1 has vertical drilling marks, indications very recent work. Sector 2, however, shows a tiered quarry face with ashlar extraction hollows.

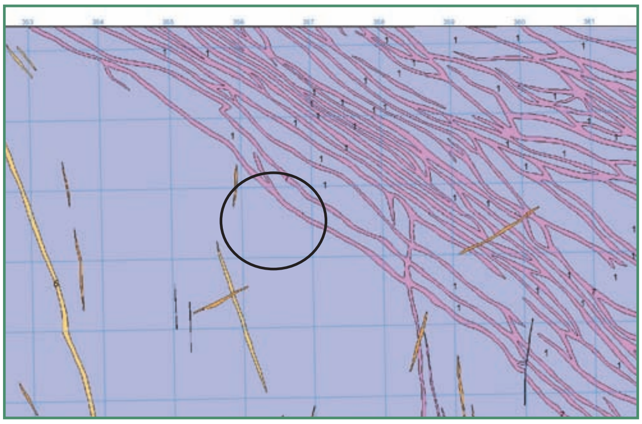
It is possible to imagine superficial millstone workings in this areas leaving little or no trace, or that recent work has erased all trace of the millstone work.

Products and dating: Construction blocks. The vertical drilling marks are probably contemporary. The ashlars, however, could be Roman or Medieval. Millstone production (still to be confirmed), judging from the post-Islamic place name, could date from the Late Medieval or Contemporary period. Roman and Medieval granite querns stored in the Historical Museum of Villanueva de Córdoba indicate local production. There is no evidence, however, that they come from this site.

Rock type: Granite. The site is in the heart of the vast Pedroches granite unit (Geological map 881, Villanueva de Córdoba, 1989). According to S. Gutiérrez, pink-coloured granite from this site is much harder than white granite and would thus have been better suited for millstone production.

View of extraction sector 1 of the quarry. This quarry face bears scars of long vertical drilling holes indicating very recent work probably with black powder (photograph by Silverio Gutiérrez).

View of extraction sector 2 (photograph by Silverio Gutiérrez). To the left can be seen the hollow of a rectangular extraction.



Extract from geological map 881 (IGME). The Piedras Molares *site is in the heart of the vast granite Pedroches unit (purple). The reddish-purple diagonal lines are adamellitic-rhyodacitic-rhyolitic porphyries and probably correspond to the two exploited sectors.*

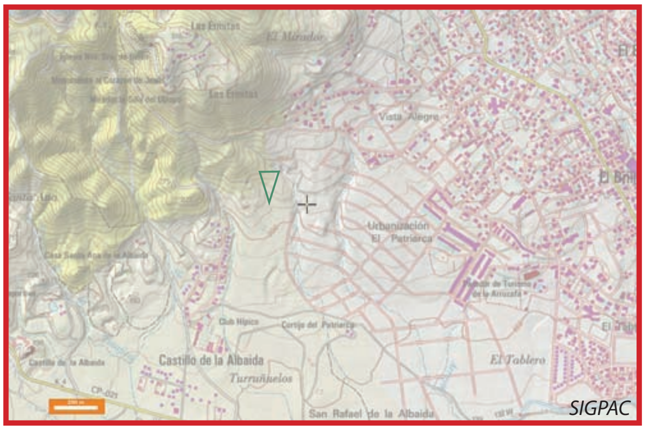
Acknowledgements

I sincerely thank Silverio GUTIÉRREZ, director of the Archaeological Museum of Villanueva de Córdoba, for the photographs and the valuable oral information.

CO-12 Córdoba

El Patriarca

Latitude: 37º 54 33.15" N
Longitude: 4º 48' 53.81 W
Altitude: 205 m



Detail of an unfinished cylinder measuring 90-95 cm in diameter (from Altamirano & Antón 2012: 334, Lám. 6).

Detail of an unfinished cylinder measuring 1,27-1,29 m in diameter (from Altamirano & Antón 2012: 334, Lám. 7).

Location: The site of *El Patriarca* is on the northwestern outskirts of the city of Córdoba at the foot of the Sierra Morena range on a low mound between two streams.

Source: The site is the object of a case study in a recent article (Altamirano & Antón 2012). To our knowledge the site is not cited in a any 18th- or 19th-century geographical work.

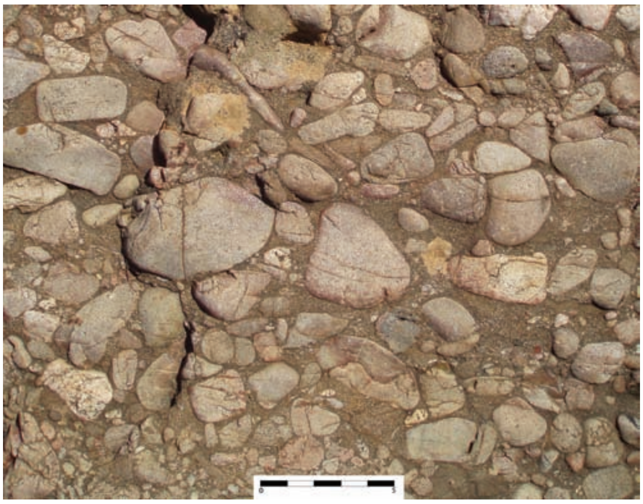
The quarry: The site comprises a series of extraction hollows and more than a dozen cylinders abandoned in different stages of manufacture. The site appears to be an extended shallow surface quarry. There is no indication of multiple extractions producing deep tubular quarry faces.

Products and distribution: Although the extractions vary in diameter from 90 cm to 1,30 m, most fall into a category of 1,20 to 1,30 m (Altamirano & Antón 2012: 335).

Techniques: The authors describe abundant parallel, diagonal lines on quarry faces (Altamirano & Antón 2012: 334). These marks indicate pick work.

Dating: Medieval or Contemporary.

Rock type: Conglomerates and sandstones (Geological map 923, Córdoba, 1973). The rock is a coarse sandstone (Altamirano & Antón 2012: 333).



Detail of the coarse conglomerate with rounded pebbles exploited at the quarry (from Altamirano & Antón 2012: 333, Lám. 1).

Extract from geological map 923 (IGME). The quarry is in a unit of conglomerates and sandstones (red) surrounded by a unit of sandy loams, biomicrites and other sandstones (yellow).

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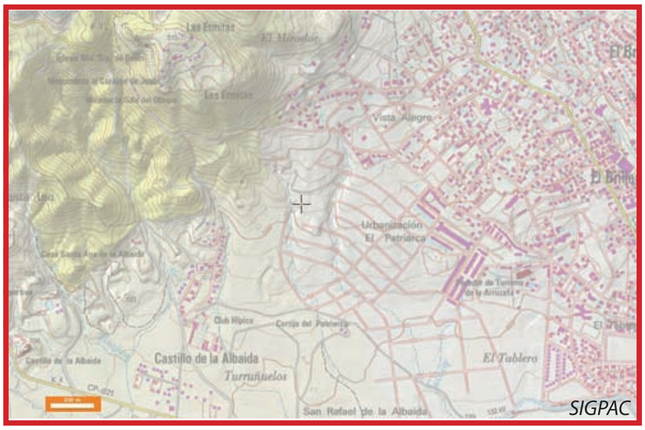
ALTAMIRANO GARCÍA, Manuel, ANTÓN AGUILAR, Lourdes. Una Cantera de Piedra de Molino Inédita en el Término Municipal de Córdoba, *Antiqvitas* 24, Córdoba. 2012, p. 331-339.

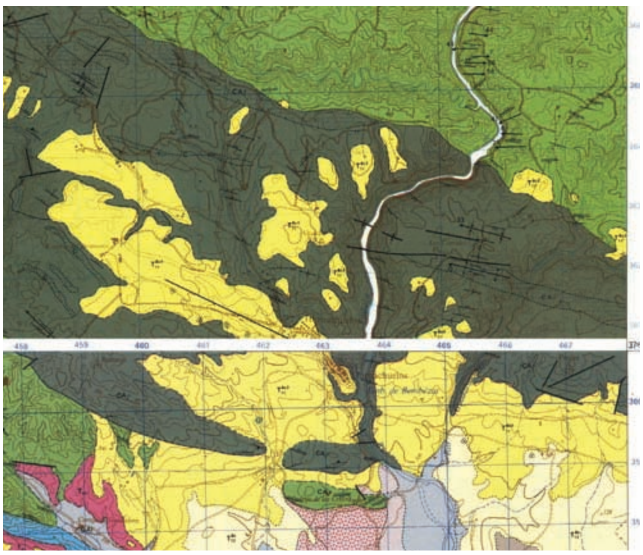
CO-13 Hornachuelos



Location: Hornachuelos is a large municipality (990 km2) in western Córdoba at the foot of the Sierra Morena. We ignore the precise location of the quarry.

Source: Two protocols recording millstone workings at Hornachuelos are noted an article about the 15th-century milling industry in Córdoba, (Córdoba de la Llave 1988: 843, footnote 24; Córdoba de la Llave 2003: 306: footnote 26. The first, dating to 1481, notes that Alfonso Fernández, a *molero* (millstone maker) from Hornachuelos, receives an advance payment of 350 *maravedis* from Antón López for an upper stone measuring 8 *palmos* to be scored at the quarry of Hornachuelos (1481.02.18, AHPC, PNCo, 14-17,3, 73r). The second, from 1486, relates that the carpenter Pedro from Vado del Aladid orders an upper stone from the quarry measuring 8 *palmos* (1486.04.02, AHPC, PNCo, 14-21, 1, 44r).

Products and quantification. The two protocols indicate that the stones are upper stones (*blancas*) and measure about 1,60 m in diameter. They were certainly destined for watermills. We ignore the scale of production at the site.



Extracts from geological map 942 and 921 (IGME). The quarry is probably to be found in the limestone (yellow) unit.

It is worth noting that this quarry is reputed to have produced only upper stones (Córdoba de la Llave 2003: 305).

Transport and distribution: It is conceivable that the stone was ferried from Hornachuelos the 40 km to Córdoba by the Guadalquivir River to Córdoba.

Dating: Late 15th century.

Rock type: Limestones and dolomites are abundant in the immediate surroundings of Hornachuelos (maps 921 and 942, IGME).

En 1481 Alfonso Fernández, molero de Hornachuelos, recibió de un molinero de Córdoba la cantidad de 350 rnrs. como parte del pago de una piedra blanca para aceña de ocho palmos en ancho "de las del molar de Hornachuelos" (1481.02.18, AHPC, PNCo, 14-17,3, 73r); pocos años después eran colocadas en una aceña del Vado del Adalid, situado sobre el Guadalquivir unos 2 km al este de Córdoba, una piedra bermeja de dos pedazos del heredamiento del Albaida, de tres palmos y medio de gordura y ocho palmos de campo, y una piedra blanca de Hornachuelos de ocho palmos, buena y de buen grano (1486.04.02, AHPC, PNCo, 14-21, 1, 44r).

(from Cordoba de la Llave 2003: 306, footnote 26).

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CÓRDOBA De la LIAVE, Ricardo. Los Molinos Hidráulicos de la Cuenca del Guadalquivir a fines de la Edad Media, Instrumental y Equipamiento Técnico, *Anuario de Esrudios Medievales*., 33/1. 2003, p. 291-337.

CO-14 Montoro district

Location: Montoro is a large municipality (589 km2) in western Córdoba along the Guadalquivir River. It has a long tradition of exploiting a reddish sandstone called "*piedra molinaza*".

Sources: The medievalist Córdoba de la Llave, based on a protocol dating from 1481 (1481.26, APC, 14-5, 3, 38 r.), signals that a lower stone (*bermeja*) for a mill in Córdoba was brought from a millstone quarry in Montoro (Córdoba de la Llave 1988: 843, footnote 22). Although there is no indication of the stone type, it is probably made from the predominant Monotro rock called "*molinaza*".

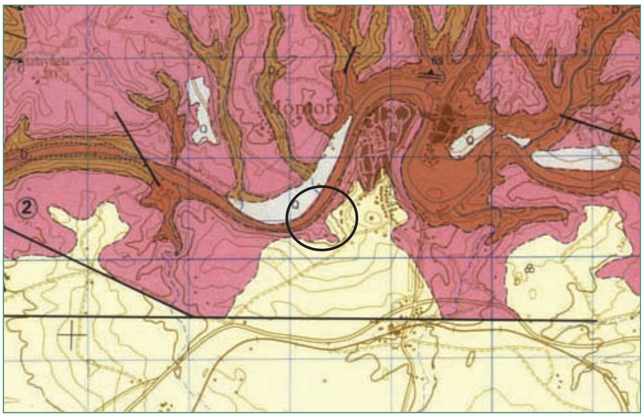
The quarries: Several small pocket exploitations are recorded in the list of archaeological sites of the Municipality of Montoro (del Pino Cutillas: no date). From the photographs it appears that the products were hewn from previously detached blocks. Outcrops of this rock are common so quarries could be widespread.

Transport and distribution: Montoro is a city built along the Guadalquivir River, the largest waterway in Andalusia. Products from Montoro could have been ferried downstream to Córdoba (about 40 km).

Rock type: The predominant rock in the area is a reddish sandstone (*Bundsandstein* facies), (Geological map 903, Montoro, 1973). This rock is known commonly as "*piedra molinaza*". The name obviously has an origin in the Latin term *mola* related to millstone. In this case, however, the term does not designate either millstones or oil rollers, but sharpening stones (Clementson 2012: 3-5). The historical archive does, nonetheless, confirm that this stone was scored for millstones at the end of the 15th century. It is worth noting that long the upper banks of the Rhine River, in Switzerland, south Germany and south France, a rose-coloured Buntsandstein, certainly similar properties to the Montoro stone, was exploited for grain mills since Antiquity (Anderson *et al*. 2003: 64-65).

*Detail of a small "*piedra molinaza*" cylinder. Quern or sharpening stone? (from del Pino Cutillas, no date: 178).*

*Views of different "*piedra molinaza*" quarries identified recently in the surroundings of Montoro (from del Pino Cutillas, no date: 178).*



Extract from geological map 903 (IGME). The reddish unit is a red sandstone (Buntsandstein). The yellow unit is a combination of conglomerates, calcarenites and loams.

Source

del PINO CUTILLAS, María Teresa, *et al*. *Carta Arqueológica de Montoro*. http://www.juntadeandalucia.es/cultura/publico/BBCC/Carta_arqueologica_Montoro.pdf [accessed June 6, 2013].

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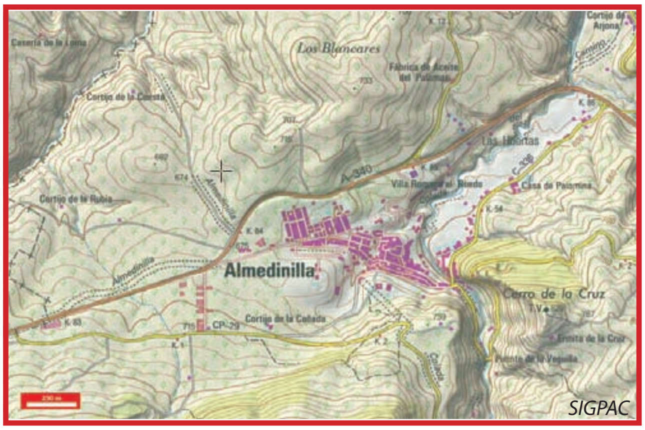
CÓRDOBA De la LLAVE, Ricardo. Aceñas, Tahonas y Almazaras. Técnicas Industriales y Procesos Productivos del Sector Agroalimentario en la Córdoba del Sible XV. Hispania. XLVIII/170.1988, p. 827-874.

CO-15 Almedinilla district



Source and generalities: Recent excavations at an Iron Age site on the top of the Cerro de la Cruz, just east of Almedinilla, revealed the tragic end of an Iberian Culture settlement toward the middle of the 2nd century BC at the hands of the Roman Army (Quesada *et al*. 2010). As a result of the fire that was set to the site, a series of mills have been brought to light in their original working position. The site also has a Medieval phase.

Products, the quarry and dating: Two models of Iron Age millstones are on the site: querns about 40 cm in diameter and larger man-driven millstone measuring more than 60 cm.

These mills are of a highly porous limestone known locally as travertine. The quarry has never been identified. It is plausible, however, that it is located at a number of outcrops on the outskirts of the town of Almedinilla, along the western bank of the Almedinilla River. A clue to the location of the quarry is the recently reported Roman ashlar quarry in a river balley about 1 km south of the Cerro de la Cruz (Muñiz *et al*. 2012: 165).

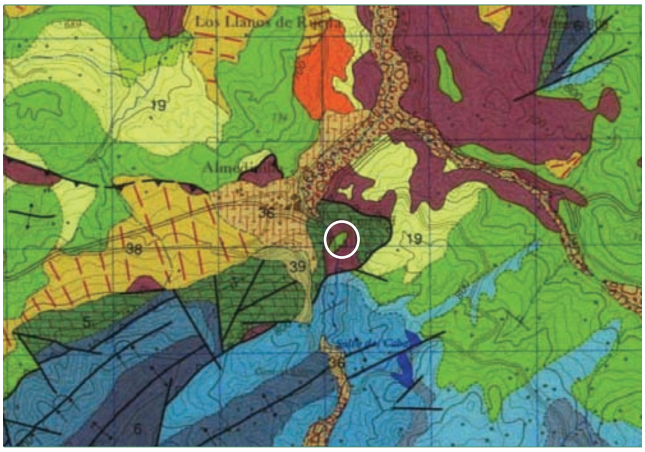
Other travertine Late Iron Age and Roman querns and millstones are known in the region and are probably from local quarries. An upper stone on display in the Museum of Alcalá la Real (Jaén) is presumably from an Iberian settlement at La Ribera Alta (to the east of Alcalá la Real), a site that is also perched on or very near a travertine outcrop (Anderson *et al*. in press). There are also Roman querns of this material in the Almedinilla Museum.

Example of a travertine lower stone of a mill in its original working position on a low, stone-built, circular podium. The mill was probably driven by pushing (photograph by T. Anderson.

Examples of travertine millstones. The ring-shaped upper stone of the mill in the background is broken an has slipped down to the level of the base of the lower stone (from http://www.rutasconhistoria.es/loc/poblado-ibero-el-cerro-de-la-cruz).

Distribution: This type of rock was favoured and widely spread in Córdoba and Granada in the Iron Age. It is impossible, however, to confirm the precise source of each millstone.

Rock type: The cream-coloured, porous limestone tufa and travertine (Geological map 990, Alcalá la Real, 1980).



Extract from geological map 990 (IGME). The Cerro de la Cruz Iron Age settlement is indicated by the circle. The millstone quarry is probably to be found in unit 36 (limestone tufas and travertines) west of Almedinilla.

Source

Almedinilla: General informtion and photograph of the site: http://www.rutasconhistoria.es/loc/poblado-ibero-el-cerro-de-la-cruz [accessed March 10, 2010}.

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Acknowledgements

I thank I. MUÑIZ, director of the Historical Musem of Almedinilla, for guiding me to the site of Cerro de la Cruz. I also thank E. KAVANAGH and F. QUESADA for access to photographs and their article scheduled to be published in the SPAL.

CO-16 Minas de Espiel district

Source and generalities: The Cuenca de las Minas de Espiel is a narrow basin in northwestern Córdoba roughly about 50 km in length and only a few km thick between the cities of Fuente Obejuna, Bemez and Espiel. It was traditionally a rich mining area. Madoz notes the presence of layer of sandstone that was exploited for the most part for millstones (1849, Vol. 14: 387). We ignore the location of these sites in this vast area.

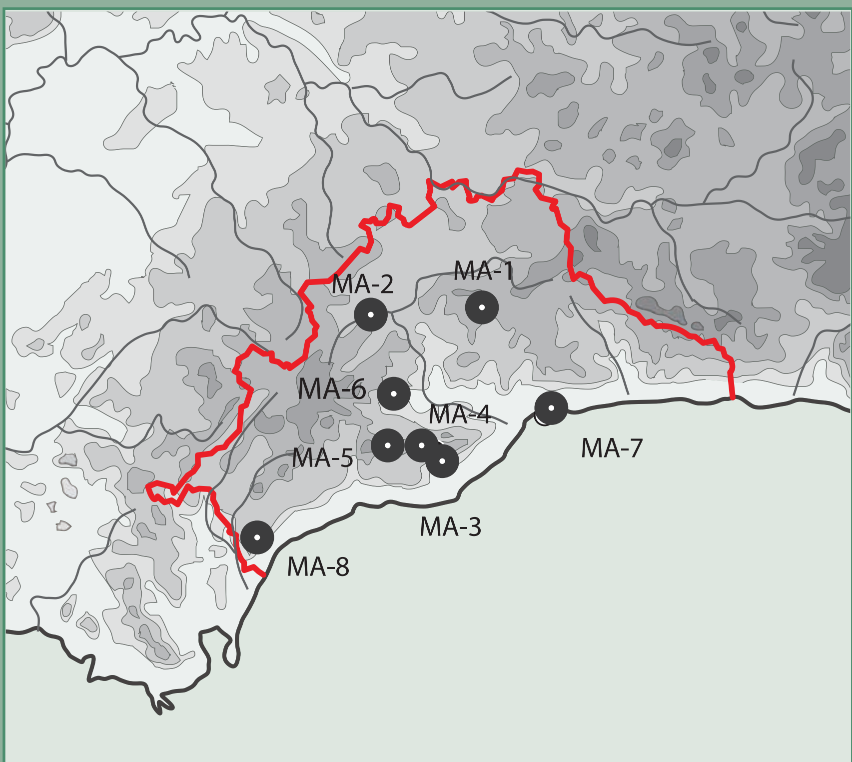
Rock type: Sandstone according to Madoz.

CO-17 Fuente Obejuna Judicial District

Source and generalities: The Judicial District of Fuente Obejuna is a very large area in northwestern Córdoba. Madoz records two "very useful" quarries for millstones and animal-driven mill along the Rivers Guadiato and Suja (Madoz 1847, Vol. 8: 230). This information is too incomplete to be able to advance any further information about these sites.

ANDALUSIA

MÁLAGA (MA)



MA-1 Antequera

El Torcal Bajo

Latitude: 36º 58′ 27.91″ N
Longitude: 4º 32′ 29.20″ W
Altitude: 950-1050 m

View from the east of the rugged, karstic landscape of the northern plateau and slope of El Torcal.

Location: The site is 6 km south of Antequera at the *Torcal* Mountain. The mountain, owing to its unique geological formations sculpted by erosion over millions of years, was declared a Natural Park in 1989. A visitor's centre and most of the more spectacular karstic formations are at the *Torcal Alto* to the south. The millstone exploitation is at the *Torcal Bajo,* off the visiter's track, on the northern edge of the mountain.

Sources: Production at this site is recorded in an historical archive (1500), cited in a study of Medieval mills in the region of Málaga (Fernández 1982: 222-223). This document records a conflict between the councils of Antequera and Málaga (30 km to the south) that found its way before the Catholic Monarchs Queen Isabella I of Castile and King Ferdinand II of Aragón. The contention, formulated by the Antequera residents, was that the *Malagueños,* because of the poor quality of their stones, intruded into their territory and took millstones for their flour mills. A second archive dating to 1508 also indicates that these mills travelled up and down the Málaga coast.

Three centuries later, a writer chronicles that the *piedra tosca* (coarse) millstones of El Torcal, destined for flour mills, are "very good" (García de la Leña 1789: 106).

Orthophoto of the rugged quarry area (SIGPAC).

View of an unfinished millstone (standing vertically) among the karstic formations. The surface slabs and boulders are often detached from the bedrock by natural processes.

A fleeting mention by Marzo in is description of the the history of the province of Málaga is a third record of millstone working at the Torcal (Marzo 1851: 496).

The quarry: The main extraction area of this "karstic" site is the plateau and slope on the northern side of the mountain where the quarrymen had a wide choice of surface material to exploit among the naturally sculpted surface slabs and boulders, often practically detached from the bedrock.

The workings are not concentrated at a single point but extend over several thousand square metres. Numerous aborted millstones are spread throughout the area. The location of the individual extractions depended on the size, shape and quality of the loose boulder or the bedrock outcrop.

Techniques: Since the tool marks are poorly preserved, it is not possible to define precisely the techniques put to use. Millstones were most likely cut into a rough shape with picks. Since many of the slabs were already naturally detached or practically loose from the bedrock, they were probably pried out with levers. This is seen in the case of one block that was poised upright so as to carve its base.

Dwelling: There are several primitive rock hovels in the area that might have served as shelters for the millstone makers or shepherds.

Products and quantification: Many abandoned cylindrical millstones measuring about 1 m in diameter in different phases of work are strewn over a vast surface. Several of the thicker cylinders might have been destined as rollers for the oil industry.

In this area there is also evidence of ancient ashlar extraction (Roman?), as well as modern block extraction (vertical boring marks for black powder). This recent work is noted in the Geological map booklet (1978: 49).

Transport and distribution: The document relating the conflict between the locals and the intruding *Malagueños* reveals that these stones travelled to the coast of Málaga shortly after the fall of Islamic rule. They would have been transported by carts through the mountains 30 km to the south along a long-established trade route linking the two cities. A second archive dating to 1508 (Fernández 1982: 221) points out that four millstones, presumably also from El Torcal, were ferried along the Mediterranean coast by Francisco Martín from the Cala del Moral to Torre de Vélez in a boat leased from Pedro de Baena and Juan de Montilla (Fernández 1982: 221).

Dating: The first historical archive places production firmly to at least the end of the 15th century. The later written sources (1789 and 1851) suggests exploitation persisted, possibly continuously, for at least three centuries. It is interesting that Madoz is silent about the site. Production may have halted at the time he compiled his geographical dictionary.

Rock type: *Rosso Ammonitico* (Geological map 1038, Ardales, 1982). The rock is a fossiliferous pink limestone. The description by García Leña of the rock as "*tosca"* (García de la Leña 1789: 106), meaning coarse and porous, is incorrect. In the Torcal area there are also white limestone outcrops.








Examples of unfinished or aborted millstones. The lower right example broke during the piercing of the eye.


Examples of abandoned cylinders. The example to the left was propped upright for carving. The cylinder to the right was probably aborted due to a central fissure that developed along the bedding plane.


Examples of thick abandoned cylinders that might have been destined as rollers for the oil industry.

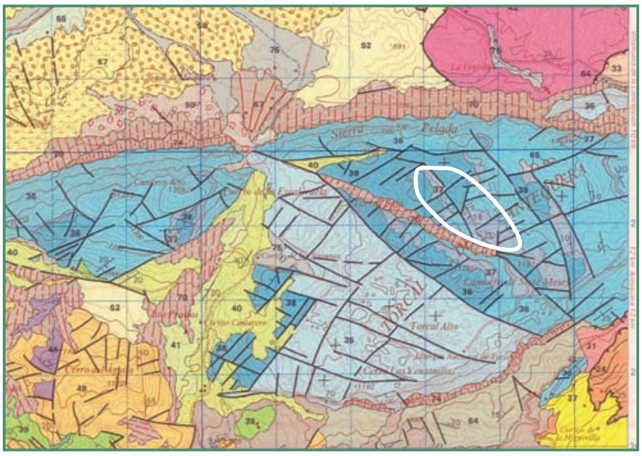

Views of solitary abandoned cylinders. The example to the left is among debris of modern quarry work.

Example of one of several drystone hovels (left) that could have served as shelters for the quarrymen. This shelter is associated with both abandoned millstones and an enclosure wall (right).

A.G.S R.G.S. XII, 1500: Sobre la escacez de la piedras de molino para pan en la tierra de Málaga.

Don Fernando e donna Ysabel y etcetera. A vos el conçejo justicia regidores cavalleros escuderos ofiçicales y omess buenoss de la çibdad de Antequera, salud e graça. Sepades que Diego Roman e Françisco de Alcaraz regidores y vezinos de la çibdad de Malaga en nonbre del conçejo della nos fizieron relaçion por su petiçion diziendo que en las syerras e treminos comunes desa dicha çibdad de Antequera ay muchas piedras para molinos de pan e que en termino de la dicha çibdad de Malaga non las ay que sean tan buenas para los dichos molinos e diz que vos el dicho conçejo justicia e regimiento de la dicha çibdad de Antequera non les dexays nin consentis sacar ni levar de vuestros terminas las dichas piedras en lo qual diz que sy asy pasara la dicha çibdad de Malaga e vezinos della resçibirian mucho danno e agravio, por ende que nos suplicavan e pedian por meçed çerca dello mandasemos proveer mandando vos que pues las dichas piedras estan en las syerras e terminos comunes desa dicha çibdad e del sacar dellas non resçiben danno esa dicha çibdad les dexasedes e consintiesedes sacar e levar de los dichos vuestros terminas las dichas piedra libremente syn ge lo inpedir o como la nuestra meçed fuese. Lo cual visto en el nuestro consejo fue acordado que deviamos mandar dar esta nuestra carta para vosotros en la dicha rason e nos tovimoslo por bien, porque vos mandamos que cada e quando qualesquier vezinos de la dicha çibdad de Malaga o de su tierra fueren o enbiaren a esa dicha çibdad a conprar qualesquier piedras para sus molinos ge las vendades e consintades vender a qualesquier personas que las tovieren o fizieren por presçios justos e razonables syn ge las encarescer e non ge lo defendades ni sobre ello fagades ligas ni defendimientos algunos e vos las dichas justiças fagades que asy se faga e cunpla e guarde de como en esta nuestra carta se contiene e contra el tenor y forma della non vayades nin pasedes ni consintades yr ni pasar e los unos i los otros e etcetera. Pena X mili maravedis con enplasamiento en forma. Dada en Granada a XXXI dias de dixienbre de mill DI annos.

Archive dating to 1501 describing the contention between the councils of Málaga and Antequera (from Fernández López 1982: 222-223).



Extract from geological map 1038 (IGME). The quarry exploited a unit of rosso ammonitico *(pink or white ammonitic limestone, light purple). White limestone (blue) was possibly also worked.*

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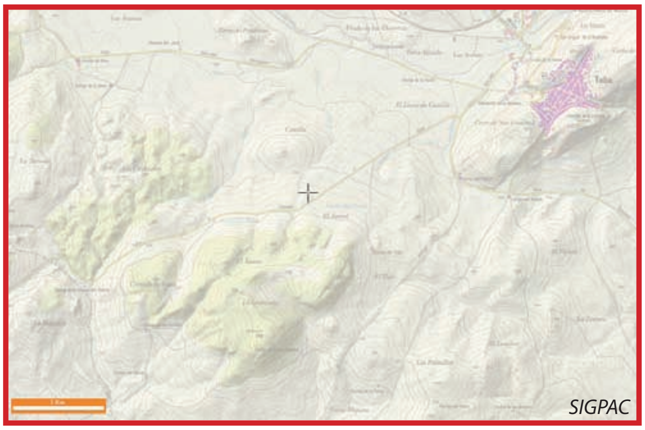
Acknowledgements

I thank Gurli MEYER, Tor GRENNE and Tom HELDAL of the Geological Survey of Norway (NGU) for accompanying me to the site and for their pertinent comments.

MA-2 Teba

El Tajo

Latitude: 36º 57' 58.28" N
Longitude: 4º 56' 54.03" W
Altitude: 650-670 m

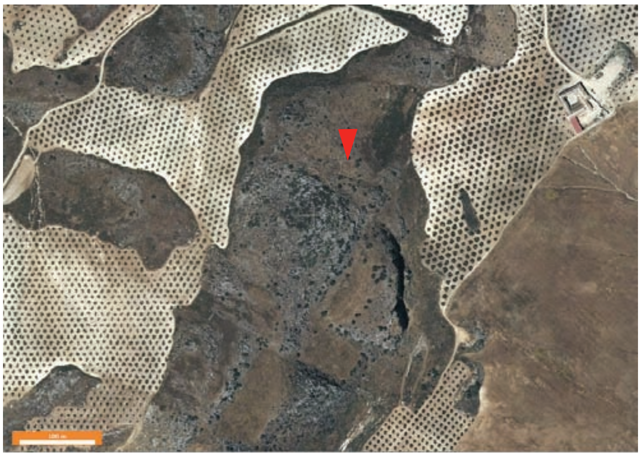


Location of the quarry of El Tajo on the Lentejuela hill. The city of Teba is to the left of the photo.

Location and toponymy: El Tajo quarry is perched on the Lentejuela mound three km southwest of Teba. The word *tajo*, in geographical terms, means ravine or gorge and could refer to the feature that cuts through the hill from east to west. A second definition of *tajo*, meaning a mine or quarry, could allude to the millstone production. The Madoz reference below suggests other quarries in the area.

Sources: Written sources date to 1833, 1848 and 1849. The first notes that Teba supplied millstones to the surrounding towns (*Diccionario Geográfico Universal,* 1833: 608). The second records that *Tera* (a the former spelling), with its population of 1000 souls, has nothing "notable except a castle in ruins, a new church and millstone quarries" (Espinosa 1848: 265). The third notes that *Teva* produces millstones from flour mills and *tahonas* that are extracted from 10 quarries of white and reddish "*jaspes*" (Madoz 1849, Vol. 14: 752).

The quarry: The site is spread over a surface of about 5000 m2 along the eastern edge of the top of the hill. Like El Torcal (MA-1), the landscape is karstic and strewn with either rounded surface boulders or small bedrock outcrops.



Aerial view of the site of Teba showing the rough, karstic surface formations (SIGPAC).

Techniques: The quarrymen cut the boulders with picks. To facilitate fashioning, they were propped up on small blocks.

Product and quantification: There are a dozen abandoned cylinders measuring systematically 1,00 to 1,10 m in diameter. The eyes of some in a more advanced state of manufacture are pierced. The site had the potential to produce a great number of millstones. Madoz indicates they are destined to watermills and *tahonas* (Madoz 1849, Vol. 14: 752).

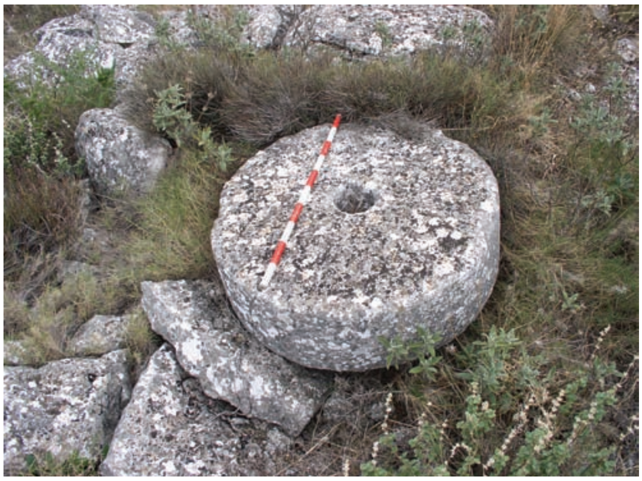
Transport and distribution: The stones were probably hauled down to the plain along the less steep western slope. A "*Cañada Real*", a traditional route for the seasonal migration of livestock, passes nearby and could have facilitated the transport to Teba and beyond.

Dating: The texts suggest working at the site in at least the first half of the 19th century.

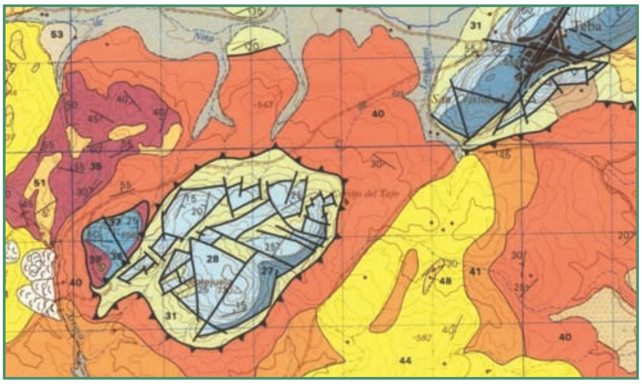
Rock type: White limestone (Geological map, 1037, Teba, 1980).

Views from the west of the quarry area on the hilltop. In the background is the town of Teba (on the mountain).

Examples of abandoned millstones in different stages of manufacture.



Examples of abandoned millstones in different stages of manufacture.



Extract from geological map 1037 (IGME). The quarry is in a unit of white limestone (light blue).

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MA-3 Alhaurín el Grande

Las Canteras

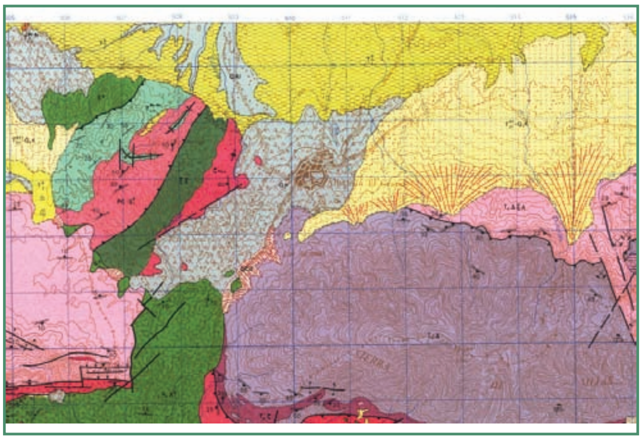
Location: Alhaurín el Grande is a town at the northern foot of the Sierra de Mijas about 10 km from the Mediterranean coast. The location of the millstone quarry has not been identified.

Sources and Toponymy: There are three written sources, spanning almost a century, that point to millstone production at Alhaurín.

The first mentions an exploitation of "*piedras toscas*" (coarse, porous limestones) at the place name "*Canteras*" (quarries) (García de la Leña 1789: 106). Madoz records several "granite" exploitations near Alhaurín el Grande (Madoz 1845, Vol. 1: 604). Finally, Marzo records millstone workings of "*almendrilla*" rock at *Las Canteras* (Marzo 1851: 426). These texts create a certain confusion. In fact, two towns, Alhaurín de la Torre and Alhaurín el Grande, about 10 km apart, share the same name and the place name *Canteras*. We suppose the millstone workings are in Alhaurín el Grande because the second and third references refer to the *Cantera* site in Alhaurín de la Torres as a marble or breccia exploitation.

Dating: The written documents place the exploitation from at least the end of the 18th to the middle of the 19th century.

Rock type: The three texts are contradictory from the point of view of petrography. The first refers to "*piedra tosca*", meaning coarse limestone, a type of stone that is in the surroundings of the town. The allusion to granite by Madoz is erroneous because granite is absent from the region. *Almendrilla*, associated with the third reference, is the diminutive of "*almendra*" (almond), and corresponds to oval-shaped clasts of coarse conglomerates or puddingstones, rocks that are also common to the region. Either limestone tufa or conglomerate (Geological map 1066, Coín, 1977).



Extract from geological map 1066 (IGME). The grey unit in the immediate surroundings of Alhaurín el Grande is limestone tufa and travertine and coincides with the text from 1789. The reference to conglomerates in the text of 1851 is not possible to pinpoint on the map.

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MA-4 Coín

Sierra Gorda

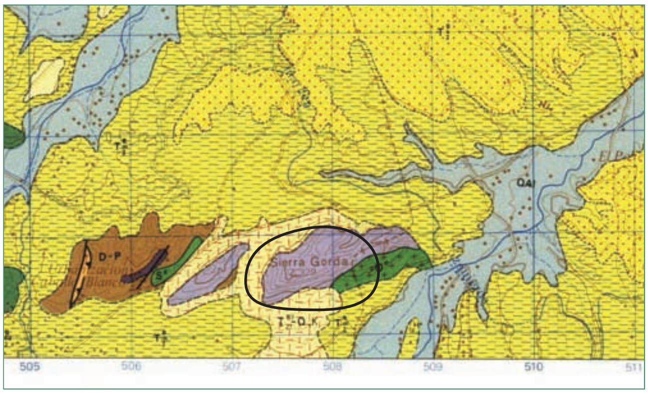
Latitude: 36º 39′ 0.78′′′ N
Longitude: 4º 45′ 41.70″ W
Altitude: 330 m

Location and source: Sierra Gorda is a hill 4 km northeast of Coín. It should not be confused with the Sierra Gorda Mountains in the western region of the Province of Granada. García de la Leña makes a fleeting reference to a millstone quarry on this hill in his general description of the uses of "*piedra tosca*" (coarse, porous limestone) in the Province of Málaga (García de la Leña 1789: 106). The location of the quarry is not assured. It might be found at a karstic outcrop (visible on the orthophotos) on the southwestern slope of the hillock, near a series of houses.

Sierra Gorda as seen from the southwest (Google Maps Street View).

Dating: The text places the millstone workings toward the end of the 18th century.

Rock type: Coarse, porous limestone, according to García de la Leña (1789: 106). Geological map, IGME, Alora 1052, 1978.



Extract from geological map 1052 (IGME). Neither the purple unit of layers of white marble nor the green unit of peridotite seems to correspond to the description of a coarse limestone. The karstic zone seen on the orthophoto is in the white marble unit.

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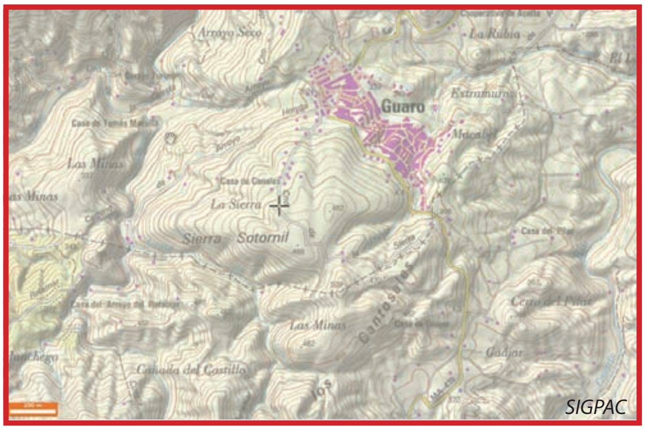
MA-5 Guaro

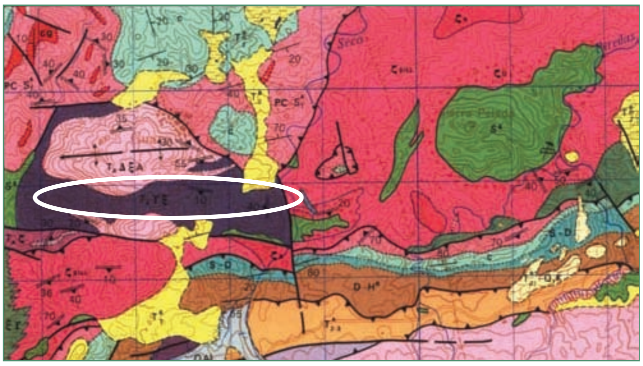


Location: Guaro is a small town in the Sierra of Mijas. The millstone production is presumably on the southern slopes of the Sotornil mountain.

Sources: The first reference to millstone workings is from Madoz who specifically cites a millstone quarry for flour mills in the Guaro Municipality (Madoz 1847, Vol. 9: 56). A second study specifies twice that the millstone quarries exploited a reddish sandstone in the mountains of Guaro (Marzo 1851: 400, 427). A third geographical study, published twenty years later, also records millstone extraction (Bautista 1861: 277). A last study, published still a few years later, corroborates the millstone workings (Bisso 1869: 20).

Dating: The texts suggest working at the site throughout a good part of the 19th century.

Rock type: A unit of reddish sandstone, clay and conglomerate is recorded to the south of Guaro (Geological map 1066, Coin, 1977).



Extract from Geological map 1066 (IGME). The quarry is probably located in the reddish sandstone unit (purple) on the mountain south of the town.

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Acknowledgements

I thank José NARANJO, historian and resident of Guaro, for his precious information about the millstone quarry of Guaro.

MA-6 Alozaina

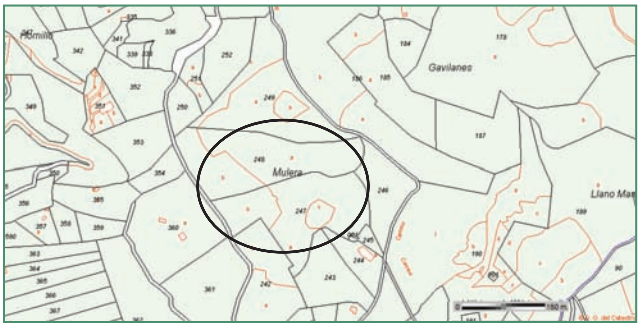
Mulera

Latitude: 36° 44′ 13.01′′′ N
Longitude: 4° 51′ 33.75′′′ W
Altitude: c. 450 m

Location: The *Mulera* millstone quarry is less than one km north of Alozaina on the southern slope of the Peñones mountain.

Sources: The geographer Madoz records that the millstone workings of "Alozayna" were of "particular merit" (Madoz 1845, Vol. 2: 186). A few years later, Marzo specifies that these millstones were hewn from a "common" rock called "*almendrilla*" (Marzo 1851: 429) meaning "almond stone" (conglomerate). This is then echoed twenty years later by Bisso (1869: 20).

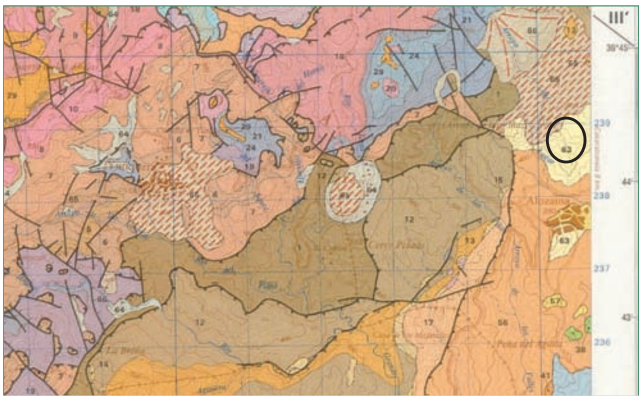
Toponymy: The 19th-century authors do not pinpoint the location of the quarry. Francisco Sánchez of the Municipality of Alozaina has informed me that there are large abandoned cylinders and animal troughs about 1 km north of the town at *Mulera*, a name that is probably a derivation of *Molera* (millstone quarry).



The location of the place name Mulera *on the cadastre (SEC) on the northern outskirts of Alozaina.*

Dating: The texts place the site in the middle of the 19th century.

Rock type: Conglomerate (Geological map 1051, Ronda, 1981). "Almendrilla" is a common name for conglomerate or puddingstone owing to the inclusions of rounded pebbles about the size of "almonds".



The quarry is in a unit of conglomerates, sandstones and clays (yellow). The rock exploited is conglomerate.

Bibliography

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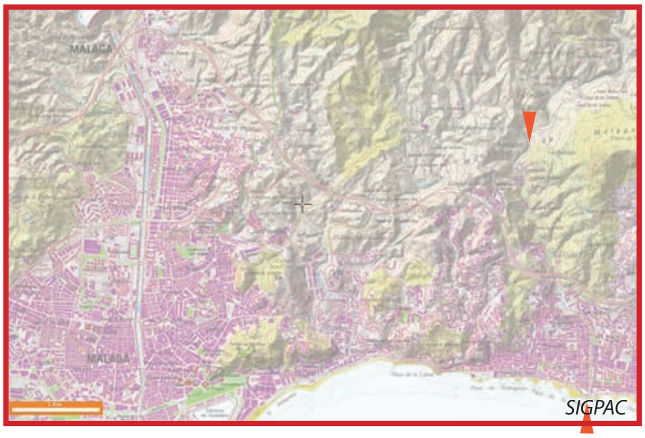
Acknowledgements

I thank Francisco SÁNCHEZ of the Municipality of Alozaina for indicating the location of the site.

MA-7 Málaga

El Jabonero



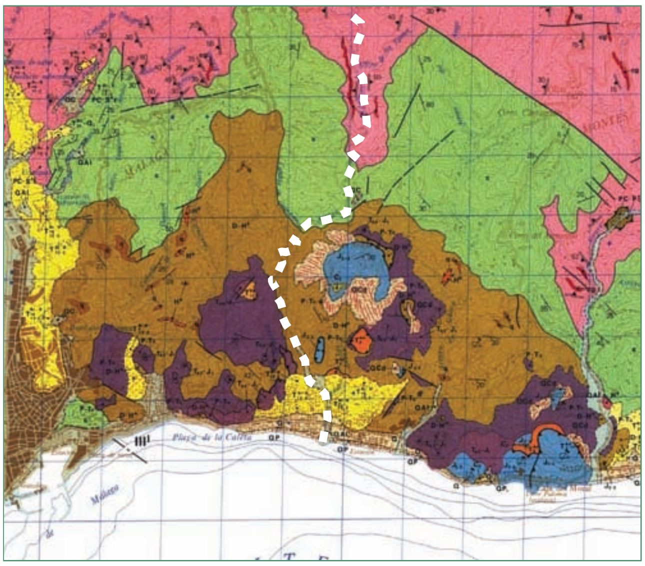
Location: The Jabonero Valley stretches 10 km from north to south through the Málaga Mountains before attaining the Mediterranean coast a few kilometres east of downtown Málaga. The location of the quarry is uncertain. With all the construction in this area over the last decades, it is unlikely that it is still conserved.

Source: García de la Leña is extremely laconic in his description of the uses of the "*piedra tosca*" (coarse, porous stone) in the Province of Málaga. He simply records that this type of rock was exploited for *"baza"* millstones in the Jabonero (García de la Leña 1789:106).

Toponymy: Toward the junction of the Jabonero Valley with the coast is the *Pedregalejo* neighbourhood. The term *pedregal* means a terrain covered by loose rocks. A quarry along the nearby slopes of the *San Telmo* hill is known to have supplied rock for the construction of the Málaga harbour (website Por las Piedras de la Historia). There is no indication, however, that this quarry also supplied millstones.

Dating: The text dates the quarry to the end of the 18th century.

Rock type: "*Piedra tosca*" and "*baza*" (coarse limestone). Geological map 1053, Málaga, 1978.



Extract from Geological map 1053 (IGME). From north to south, the Jabonero Valley (white broken line) crosses units of a) phyllites and meta sandstones (pink); b) limestones (green); c) greywackes and phyllites (brown); d) sandstones, conglomerates, gypsum and loams (purple); e) piedemonte (mountain foot) rocks devoid of calcareous crust (yellow); f) alluvial (light grey); and g) undifferentiated (beige). The site could be anywhere in the a, b, d and e units.

Source

Website: Por las Piedras de la Historia, Recorido por Málaga: http://www.alhaurin.com/alandalus/Municipios%20andaluces/Malaga/Recorrido2.htm [accessed November 13, 2012].

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MA-8 Casares

Sierra de Utrera Karst

Latitude: 36º 23' 20.45" N
Longitude: 5º 16' 23.02" W
Altitude: c. 200-250 m

Location: The Sierra de Utrera is a mountain (4 x 3 km) in the southwest corner of the Province of Málaga. It presents a rugged, karstic landscape similar to that of El Torcal (MA-2) and Teba (MA-2).

Sources: The Royal Survey of Tomás López (1780), the oldest written reference, records that a quarry worked a white rock for the columns for an important church in Cádiz and for millstones to flour mills.

A second source, a geological study, notes that the Utrera mountains are spotted with *piedras caballeras* that served for millstone making (Gómez Zotano 2003: 140). *Piedras caballeras* are rounded boulders resulting from a process of dissolution in which each boulder ends up perched on a far smaller rock base.

The quarry: The millstone makers had the choice of exploiting either individual surface boulders or bedrock. We ignore if the modern quarry at the southern base of the mountain has erased the millstone workings reported in the 1780 survey. In any case, this production should not be confused with the celebrated whetstone workings from the neighbouring Municipality of Manilva cited in texts from the 18th and 19th centuries.

Dating: The old written sources indicate working at the end of the 18th century.

Rock type: Limestone. The geological map is not available.

Orthophoto of the Karst of the Sierra de Utrera. The modern quarry is visible at the bottom of the picture (SIGPAC).

Views of the karstic landscape of the Sierra Utrera. The exact location of the quarry is not known (photographs from http://grupoextremo.blogspot.com.es/2012/09/casares-banos-de-la-hedionda-canuto-de.html).

Extract of the Survey of Tomás López (1780)

"...Naze esta de la falda de una Sierra llamada la Utrera, no es muy alta tiene cantera para sacar piedras para molinos de pan, tira a Jaspe blanco, y de dicha cantera se sacaron las quatro colunas que adornan el frontispicio de la portada de la Santa Yglesia de Cadiz ..."

Sources

Tomás López Survey answers in: http://www.iluana.com/galeria_ficha.asp?idgaleria=82&size=large&idfotografia=10129 [accessed October 22, 2012].

Photos from: http://grupoextremo.blogspot.com.es/2012/09/casares-banos-de-la-hedionda-canuto-de.html [accessed December 16, 2012].

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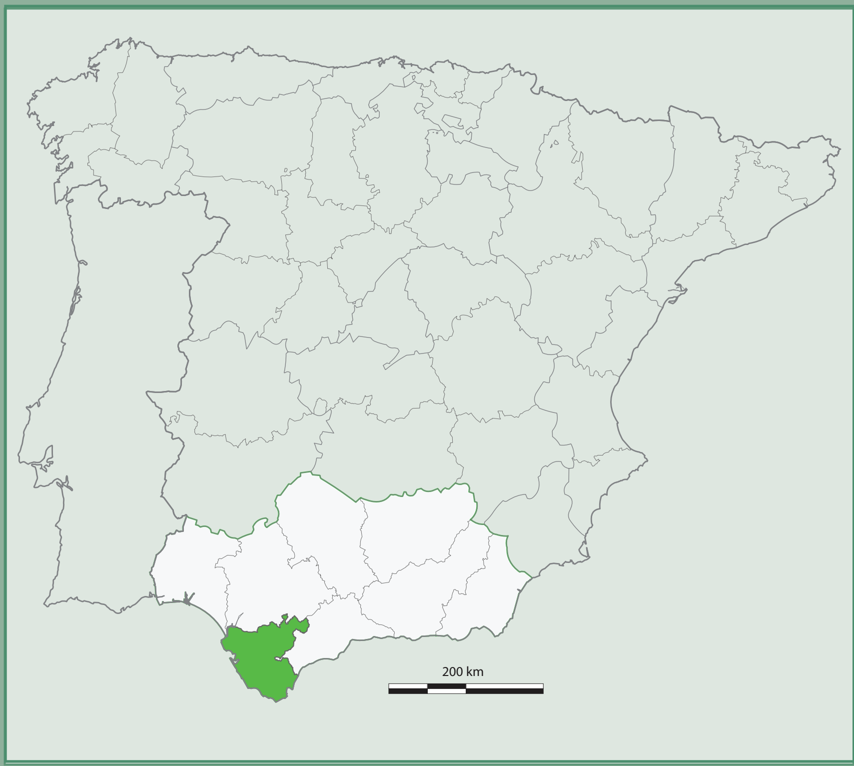
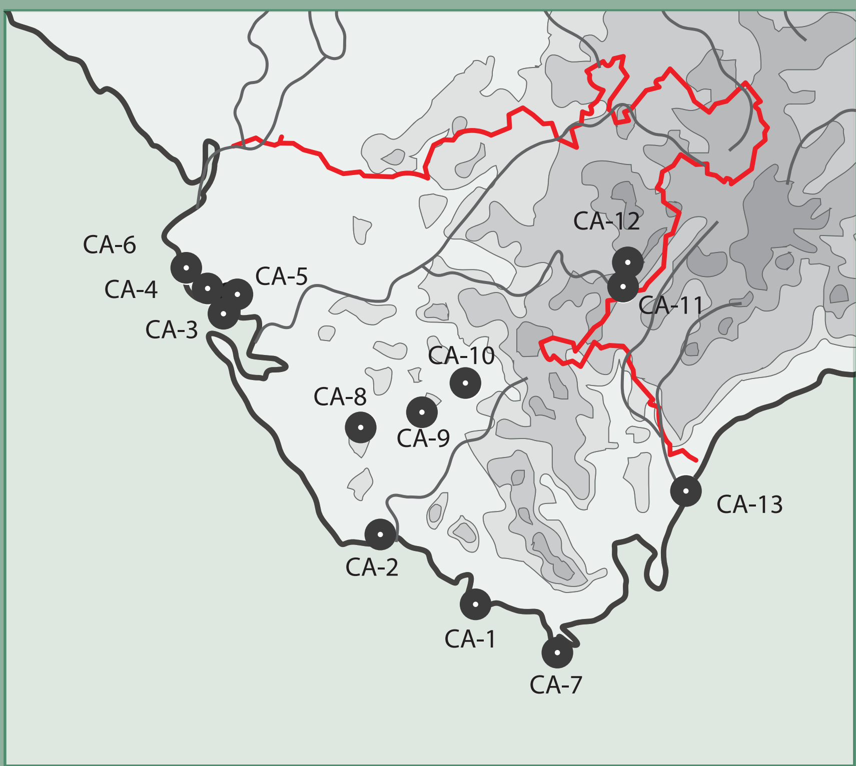
ANDALUSIA

CÁDIZ (CA)





CA-1 Barbate

Bay of Trafalgar, Playa del Faro

Latitude: 36º 10’55.16” N
Longitude: 6º 1’49.75”W
Altitude: 0-1 m

View from the west of the eastern sector of the Trafalgar quern quarry.

Location and generalities: The quern and millstone quarry of Trafalgar is on the Atlantic coast on the Bay of Trafalgar, scene of the famous naval battle of 1805.

Source: The site, brought to the attention of A. Belmont by a French geologist, is not recorded in any of written test. Since our first visit several years ago, we have referred to the exploitation in several articles (Anderson 2011: 231-232, 236; Anderson & Scarrow 2011: 267-268).

The quarry: The site, a shallow surface quarry, can be divided roughly into two major sectors. The eastern sector, limited to a surface of about 150 m2, presents many small contiguous hollows corresponding to rotary hand-quern extractions. The rest of the site, on a surface of about 100 x 20 m and partially under water during out visit, shows larger millstone hollows. Owing to erosion by wind and water, the quarry’s surface is smoothed over and reveals no tool marks.

Products and quantification: The querns from the eastern sector measure about 40 cm in diameter. Their number is in the low hundreds. The rest of the quarry produced hundreds of discs measuring between 80 cm and 1,10 m in diameter. These correspond, presumably, to stones for either wind, water or animal-driven mills.

Transport and distribution: The location of the site on the coast, and certainly under water at high tide, facilitated maritime transport. Rotary querns of this characteristic rock are found on Roman settlements both up and down the Atlantic and part of the Mediterranean coast.

Dating: The date of the different sectors is impossible to determine with confidence. Rotary querns of similar dimensions have been brought to light at the Roman cities of *Baelo Claudia, Carteia* and *Iulia Traducta.*

The diameter (80 cm to 1,10 m) and discoidal shape of the extractions of the second sector suggest a Medieval date. But, once again, the chronology is not secure. In any case there is no evidence of rmore recent extractions over 1 m in diameter.

Rock type: Shell-rich conglomerate (Geological Map 1076, Barbate, 1983). This facies is very similar to the yellowish, porous *piedra ostionera* (oyster stone).


Details of the circular hollows corresponding to rotary querns measuring approximately 40 cm in diameter. The extractions follow the inclined bedding plane of this sector of the bedrock.




Views of the larger extractions corresponding to millstones measuring approximately 80 cm in diameter.

Views of the larger extractions corresponding to millstones measuring approximately 80 cm in diameter.

Before and after views the western sector of the quarry illustrating the shifting sand deposits that periodically cover the quarry floor.

Detail of the ostionera *(biocalcareninte) rock.*

Extract from geological map 1076 (IGME). The light grey unit (no. 29) is a conglomerate with shells.

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Acknowledgements

I thank Alain BELMONT for relaying the information of this site's existence.

CA-2a Tarifa

Punta Camarinal

Latitude: 36º 5′ 1.23″ N
Longitude: 5º 47′ 14.95″ W
Altitude: 1-30 m

View from the west of one of the faces of the monumental Roman Punta Camarinal block quarry (photograph by Manuel L,http://www.rutasyfotos.com/2011/09/duna-de-bolonia-punta-camarinal-cabo-de.html).

Location: The Punta Camarinal is on the eastern edge of the Camarinal Point that juts into the Atlantic about 1 km west of the Roman city of *Baelo Claudia* (Bolonia). The site was exploited in both along the coastline and on the inland mound called the Monte Camarinal.

Sources: The quarry is described briefly in the book about the Roman city of *Baelo Claudia* (Sillières *et al*. 1997: 71-72).

The quarry and products: The site is a vast monumental exploitation with extensive vertical quarry faces. This *ostionera* sandstone quarry, along with the limestone *jabaluna* quarry of San Bartolo (about 4 km to the southeast of *Baelo Claudia*), provided most of the building material of the Roman city of *Baeolo Claudia*.

This quarry delivered ashlars, jambs, and column drums and capitals to *Baelo Claudia* (Román 2007: 21). There is, however, no direct evidence of millstone production. It is, nonetheless, probable that at least a part of the 40 *ostionera* rotary querns in the depository at the *Centro de Interpretación* of the Roman city come from Punta Camarinal. In any case there is possible evidence that millstones in *Baelo Claudia* were recycled from construction material originating in a nearby quarry (see also CA-2b). This is seen by a circular hollow, corresponding to the size of a rotary quern, carved into a construction block at the city.

A second example of re-use of construction material is an unfinished Pompeian upper stone discovered in an old excavation (Anderson *et al.* 2012, submitted.

Transport and distribution: Transport by water of construction material was facilitated by its proximity to the coast.

Dating: Roman.

Rock type: *Piedra ostionera* facies, a yellowish, porous, shell-rich rock (Geological Map 1077, Tarifa, 1983).

Example of a circular extraction (quern?) scored from a recycled block in the Roman city of Baelo Claudia *(photograph by Ivan García).*

*Example of an unfinished upper stone (*catillus*) at the Roman city of* Baelo Claudia, *probably recycled from construction material.*

Extract from geological map 1077 (IGME). Unit 22 is conglomerate containing shells cemented together.

Sources

Photograph of the quarry from blog of Manuel L.: http://www.rutasy-fotos.com/2011/09/duna-de-bolonia-punta-camarinal-cabo-de.html [accessed October 20, 2012].

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Acknowledgements

I would like to thank Ángel MUÑOZ (director) and archaeologists Ivan GARCIA and Franciso ROJAS of the *Baelo Claudia* Centre of Interpretation for information about the local quarries and for opening up the depository of the centre to study the querns and millstones.

CA-2b Tarifa

Paloma Alta

Latitude: 36º 4′ 21.78″ N
Longitude: 5º 43′ 52.79 W
Altitude: c. 150 m

Location and generalities: The Paloma Alta quarries are 5 km southeast of the Roman city of *Baelo Claudia*. Most of the extraction took place on the upper slopes overlooking the coastline. Other work took place along the coast. Millstone working is not certified. However, this quarry, along with that of Punta Camarinal (CA-2a), is a possible source of building material that could have later been recycled into millstones at *Baelo Claudia*.

Source: This quarry is mentioned in the study of *Baelo Claudia* (Sillières *et al*. 1997: 71-72). Unfortunately, like the site of Punta Camarinal, no formal study of the quarry has been undertaken. Pictures of the site are posted in a hiking itinerary available on the internet (see source).

The quarry and products: True extractive quarry for construction blocks and drums for columns. The drums are extracted both on horizontal and vertical planes.

Dating: Roman.

Rock type: Calcarenite or *ostionera* (Geological Map 1077, Tarifa, 1983).

Example of an abandoned column drum measuring about 1 m in diameter. This drum was extracted on a vertical plane in the upper sector of the quarry (photograph from blog Canteras Romanas de la Palomo Alta).

Example of a drum abandoned before extraction. This example, in the lower sector of the quarry, was cut following a horizontal plane (photograph from blog Canteras Romanas de la Palomo Alta).

Extract from geological map 1077 (IGME). The rock of the quarries, calcarenite, does not correspond with the information from the geological map (dunes).

Source

Hiking itinerary: "Canteras Romanas de Paloma Alta": http://dcaminata.wordpress.com/2013/01/08/canteras-romanas-de-paloma-alta/ [accessed December 28, 2012].

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CA-3 Rota

Playa de la Costilla

Latitude: 36º 37’9.18”N
Longitude: 6º 21’51.23”W
Altitude: 0-1 m

View from the southeast of the Playa de la Costilla where abandoned quern and millstone extractions emerge at low tide (photograph by T. Anderson)..

Example of an unfinished hand-quern (photograph by Prudente Arjona).

Location and generalities: Extraction of millstones took place on outcrops along the Altlantic coast on both sides of the present lighthouse of Rota at the *Playa de la Costilla* and the *Playa del Rompidillo*. The construction of the new port between these two beaches, according to P. Arjona, destroyed part of the quarry.

Sources: The information and photographs gathered about this site come from a report on the internet by the local historian P. Arjona. Further information from old legal archives was provided by J. A. Martínez, the chronicler of the city of Rota.

Martínez’s research in the archives has brought to light records narrating a contention in 1719, between the governor José de Velasco y Montoya and the residents Pedro Martín Pimienta and Juan de Vargas for extracting millstones illegally from the Rota beach. Furthermore, this research has revealed that in 1745, the Municipal authorities reinforced the prohibition of millstone extraction unless a tax, reduced to half of its original value, was paid.

The quarry: The site, only visible at very low tide, falls into the category of a shallow surface quarry. Extractions are not concentrated in one single area, but spread out along the outcrops.

Products and quantification: Both handquerns and millstones were produced. The querns measure approximately 40 cm in diameter. The millstones are much larger, measuring more than a meter.

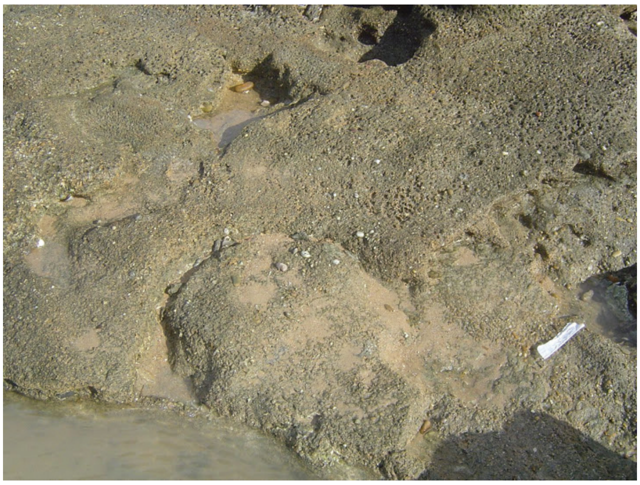
Transport and distribution: In his report about flour mills in Rota, Arjona cites a source (Ponce 1981) that relates that two 19th-century Portuguese ships (“*Felicidade*” and “*O que Deus Quera*”) sailed from their home port to acquire millstones at Rota. This information indicates that the Rota production was highly prized and travelled beyond the local sphere.

Large millstones, probably recent, are reported at a shipwreck south of this site (Martí & Rodríguez 2003: 412-413). Although the authors suggest that they come from a quarry at the Punta de Nao (City of Cádiz), it cannot be excluded they come from Rota.

Dating: The hand-querns are probably Roman. The millstones, based on the written sources, date from Modern and Contemporary times.

Rock type: Shell-rich o*stionera* rock facies a yellowish, porous, oyster conglomerate (Geological Map 1061, Cádiz, 1984). The hardness of the stone is illustrated by the anecdote by Prudente Arjona that during recent construction of the port, the bits to drill the vertical holes often had to be replaced due to the rock's resistance.

Examples of large millstone extractions (all photographs by Prudente Arjona).



Examples of small rotary quern extractions (photos by Prudente Arjona).

Extract from geological map 1061 (IGME). The green unit (no. 10) is a shell-rich conglomerate. The dotted strand along the shoreline are the sands and shells of the present beaches.

Source

Prudente ARJONA LOBATO, Historias Populares de Rota: Molinos, Tahonas y Tahoneros (II), Cosas de Andalucía: http://www.cosasdeandalucia.com/web/index.php/memoria-historica/nuestros-ayeres/1658.html [accessed November 25, 2012].

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Acknowledgements

I thank Prudente ARJONA, local historian and José Antonio MARTÍNEZ, city chronicler, for information about the quarries and for permitting the use of photographs of the site.

CA-4 Rota

Playa de Aguadulce

Latitude: 36º 40’ 17.48” N
Longitude: 6º 24’ 37.20” W
Altitude: 0-1 m

Location: Playa de Aguadulce is on the Atlantic coast of the about 7 km north of the quern and millstone quarries of the city of Rota (CA-3).

Source and the quarry: J. A. Martínez, the chronicler of the city of Rota, reports that an older resident of the city recalls that his father, a miller, ordered a millstone that was extracted at the Playa de Aguadulce. No quarry has been identified at this location. This extraction was probably isolated and production never reached a large scale.

Dating: This unique isolated extraction probably dates to the middle of the 20th century during the period of economic hardship after the Spanish Civil War.

Rock type: *Piedra ostionera* facies (conglomerate rich in oyster shells), Geological Map 1061, Cádiz, 1984.

Extract from geological map 1061 (IGME). The green unit (no. 10) corresponds to the shell-rich conglomerate. The dotted unit along the shoreline are the sands and shells of the present beaches.

Acknowledgements

I would like to thank José Antonio MARTÍNEZ, Chronicler of Rota, for taking the time to interview a group of older residents of Rota and gather precious oral information about millstone production.

CA-5 Rota

Roa Martín (Ramos Martín)

Latitude: 36º 39′ 55.95″ N
Longitude: 6º 22′ 53.05″ W
Altitude: 20 m

Location and generalites: The quarry of Roa Martín (or Ramos Martín) is 2 km from the Atlantic coast near the present military base. This is a unique exploitation. In the middle of the 18th century, it was destined for construction material. Two centuries later, however, it became a source of composite millstones.

Toponymy: The names *Canteras* and *Pedreras* (both meaning quarries), adjacent to the place name *Roa Martín,* appear respectively on the geographical map and the cadastre and both names are certainly related to the old rock extraction.

Sources and the quarry: A municipal record dating to 1756 (conserved in A. H. N. A. H. N., Nobleza, Osuna, libro 19, 104), studied by J. A. Martínez, the chronicler of the city of Rota, states that due to the scarcity of rock in the town of Rota, the town authorises builders to extract stones from the quarries of *Ramos Martín*. Millstone production with stones of this quarry dates to the 1940s-1950s. J. A. Martínez relates that a local craftsman (possibly called Miguel Laínez Ruiz) in the 1940s-1950s assembled millstones of different sizes with rock fragments recovered from the quarry of Roa Martín. He cut the rocks into segments and bounded them with concrete in moulds. This type of local production, assembling millstones (probably following the example of French Burrs), is not surprising considering the harsh post-Civil War years.

The place name Pedreras *(quarries) appears in place of* Canteras *(extract from the cadastre (SEC).*

Product and quantification: Composite or segmented millstones. This site is an example of a very modest local production.

Dating: The block quarry dates to the middle of the 18th century. Millstone production, however, is only recorded in the 1940s-1950s.

Rock type: According to the Geological map, the rock in this area is the shell-rich *ostionera* conglomerate (Geological Map 1061, Cádiz, 1984). J. A. Martínez, however, recalls that the rock at this location is a reddish sandstone corresponding to the rock unit 13 west of the site on the Geological map 1061 (IGME).

Extract from geological map 1061 (IGME). The quarry exploited a shell-rich conglomerate (yellow with reserved T symbol). The information provided by J. A. Martínez would point to a reddish sandstone corresponding to the yellow 13 unit.

Source

Prudente ARJONA LOBATO, Historias Populares de Rota: Molinos, Tahonas y Tahoneros (II), Cosas de Andalucía: http://www.cosasdeandalucia.com/web/index.php/memoria-historica/nuestros-ayeres/1658.html [accessed November 25, 2012].

Acknowledgements

I would like to thank José Antonio MARTÍNEZ RAMOS and Prudente ARJONA for their valuable information about this millstone quarry.

CA-6 Chipiona

Playa de las Canteras

Latitude: 36º 44′ 20.26″ N
Longitude: 6º 26′ 30.27″ W
Altitude: 0 m

View from the south of the millstone quarry of Chipiona. At the moment of the photograph the quarry was underwater. In the foreground are undated traces of block extractions and in the background the ancient fish corrals.

The place name Las Canteras *persists as the name of a street near the quarry (extract from the cadastre, SEC).*

Location: This quarry is on the coast of the city of Chipiona between the lighthouse and the ancient fish corrals. During high tides the site is completely covered by water.

Toponymy: Although the place name *Las Canteras* no longer appears on the geographical map, it remains on the cadastre as the name of a street near the site. It is however not known if the name is related to the millstone or the block exploitation.

Sources: The site is identified as a millstone quarry in a study of a Roman villa (Ramos & Riesco 1983). A more recent study interprets the circular hollows as basins to evaporate sea water to harvest salt (Alonso *et al.* 2003, 322). Due to the existence of *ostionera* querns and millstones on settlements along the Atlantic coastline, we tend to follow the first interpretation. Holes in the bedrock might have served as receptacles to evaporate sea water for salt. But in here it seems improbable due to flooding during high tides. Besides, most of the extractions are along the edge of the rock and never could have held water.

The quarry: Like other coastal exploitations, this appears to be a true extractive, shallow surface quarry.

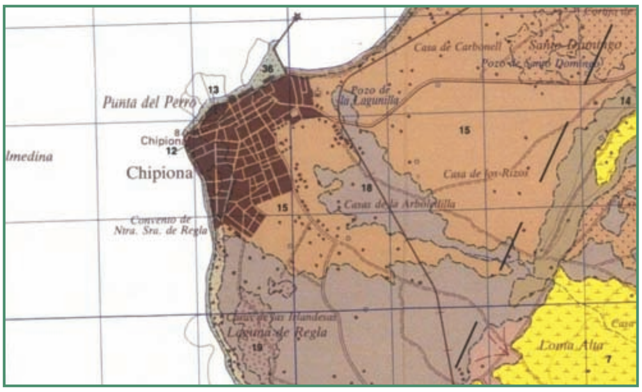
Product and quantification: The hollows and abandoned millstones correspond to cylinders measuring 1,20 - 1,25 m in diameter. Due to the difficult conditions of observation, their number is not possible to quantify. If the outcrop originally extended to the north, an area now devoid of rock, then the production could have been great. There is no evidence of quern extractions, as is the case of other *ostionera* quarries.

Transport and distribution: These workings on the coast benefited from maritime transport.

Dating: The size of the extractions suggests an exploitation that could date from Medieval to Contemporary times.

Rock type: *Piedra Ostionera* (Geological Map 1047, Sanlúcar de Barrameda,1984). Yellow shell-rich sandstone.

Views of extraction hollows and abandoned cylinders corresponding to millstones measuring approximately 1,20-1,25 m in diameter.



Extract from geological map 1047 (IGME). The quarry is in the thin shoreline ostionera *unit (no. 12).*

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CA-7 Tarifa

Isla de la Paloma

Latitude: 36º 0' 13.16" N
Longitude: 5º 36' 23.73" W
Altitude: 0-5 m

Location: The Isla de la Paloma is a minute island (500 x 400 m) linked by a jetty to the port of Tarifa. It is the southernmost extension of the Iberian Peninsula and features a lighthouse, an 18th-century fortification and a number of quarries where building material had been scored since Roman times.

Sources: A scuba diving itinerary (Magariño & Sánchez 2007: 369) reveals the presence of several millstones in the waters along the eastern coast of the island that presumably come from a nearby coastal quarry.

The quarry: There are a number of *ostionera* block quarries recorded along the coastline of the island. One is opposite the location of the sunken millstones. There is, however, no evidence of millstone working in these exploitations. A hypothetical earlier millstone quarry could have disappeared in the 19th century during to the massive block extractions for the fortification.

Product: The dimensions of the millstones are not recorded.

View from the north of the island (extract from Google Maps Street View).

Transport and distribution: The presence of sunken millstones is evidence of maritime transport.

Dating: Unknown.

Rock type: A geological study identifies the rock as a shell-rich sandstone *piedra ostionera* (Román 2007). This coincides with the data of the Geological map (Geological Map 1077, Tarifa,1983).

Extract from geological map 1077 (IGME). The quarries exploited a shell-rich conglomerate (unit 22). The yellow unit (no. 14) is made up of loams and mica sandstones.

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Acknowledgements

I thank Iván GARCÍA, archaeologist at the Centro de Interpretacíon of the Roman city of Baelo Claudia, for information about this site.

CA-8 Medina Sidonia

El Berrueco

Latitude: 36º 27' 4.89" N
Longitude: 6º 2' 20.30" W
Altitude: 70-100 m

View from the hilltop town of Medina Sidonia of the Berrueco mountain. The city of Chiclana on the Atlantic coast is in the background to the left and the Bay of they city of Cádiz is to the right.

Orthophoto of the Berrueco Mountain (SIGPAC).

Location and generalities: The Berrueco Mountain is halfway between the hilltop town of Medina Sidonia and Chiclana, a city on the Atlantic coast.

Toponymy: The toponym *Berrueco* is generally associated with granite, a rock that is not known south of the Guadalquivir River Basin. It is, however, often identified with granite quarries elsewhere on the Iberian Peninsula, for example, at the town of Berruecos, Madrid (M-1), known for its granite quarries. Due to the rarity of this place name in this region, we speculate that the toponym was imported from the north of Spain after the fall of Islamic rule.

Sources: This site is one of the few that benefits from more than a simple passing written reference. There are several different sources spanning almost a century.

The oldest record of this quary comes from a historical archive of Vejer de la Frontera dating to 1509, which indicates that Berruecos furnished the watermill "La Teja" with a millstone (http://www.patrimoniojandalitoral.es/f_vai_8.htm).

An indirect reference to the site comes in the response to the Census of the Marqués de Ensenada (1750-1754) that records that in Medina Sidonia, there are eleven millstone makers (six are *oficiales* and 5 *maestros)*. Although it cannot be confirmed, these men probably procured their rock at the Berrueco quarry.

A third reference is a late 18th-century historical treatise penned by the priest of Medina Sidonia (Martínez y Delgado 1875). It is important to note that this work was only published in 1875, about a century after the death of the author. The events taking place in the account, however, are set toward the end of the 18th century.

The priest recorded that there was a vast "mine" of white, grainy stone exploited for mills and "*atahonas*" (animal-driven flour mills). He also records that the quarry furnished stones to the cities and towns of the region, granting the millstones makers, residents of Medina Sidonia (9 km away), an "advantageous" daily wage (Martínez y Delgado 1875: 129).

View from the east of the Berrueco quarry site. The installations of the 1960s for block extraction and quicklime production are in the centre at the foot of the mountain.

A generation later Cruz y Bahamonde, in a treatise on the commerce of Cádiz, noted that at the top of the Berrueco mountain there were dwellings that accommodated about 50 millstone makers. These workers produced millstones that were favoured over those from other quarries and that the quarry was the property of the Duke of Medina Sidonia who received 18 millstones a year in exchange for the concession (Cruz y Bahamonde 1813: 91, note 1).

The geographer Madoz alludes to the site on three occasions. Two are simple fleeting references (Madoz 1846, Vol. 5: 139-140; Madoz 1848, Vol. 11: 343), whereas the third reveals that the quarry was made up of five different workshops occupied by 23 men who resided at the site. These millstone makers retained the right to bear "arms" (explosives) not only because they had the obligation to level some crags around the city of Medina Sidonia, but because they chased down the "*rateros*" (thieves) that at times appeared in the area (Madoz 1846, Vol. 4: 290).

The quarry: There are no longer visible traces of the old millstone production. The installations visible today on the eastern slope correspond to the last phase of work at the site dating to the 1960s when blocks were extracted for construction of the port of Rota or crushed for quicklime production. The heart of the mountain is now a vast crater, indicative of a vast pit exploitation. However, no old quarry faces are visible.

Product and quantification: According to Madoz the yearly production consisted of a maximum of 64 millstones for water or windmills and 480 "*granos*", a term that specifically designates stones destined for animal-driven flour mills. The stones were rounded at the site and sold ready for use (Madoz 1846, Vol. 4: 290). We ignore if this included the cuttings for rynds. The millstones from this site were obviously of superior quality and probably could be counted in the thousands. We ignore, however, their size. Since Madoz clearly indicates a difference between the stones for water or windmills and stones for animal-driven mills, then we can assume that they may have differed in size and thickness.

Transport and distribution: According to the different sources, Berrueco millstones were traded over all of the region. The oldest reference, cited in a website about the history of Vejer de la Frontera, indicates millstones arriving at the town in 1509. The transport of these products to the town of Puebla de Guzman (Garrido 2001: 167) 170 km away, is evidence that they were commercialised beyond the local sphere. The position of the quarry along the road linking Medina Sidonia to Chiclana would have facilitated land transport to the port of Chiclana where they could have been loaded on boats for maritime transport.

Dating: This sites was presumably active, based on old written sources, in early 16th century and then in the 18th through at least the middle of the 19th century. It is conceivable that the site operated continuously between those dates.

Bread: Martínez y Delgado suggests that the Berruecos rock yields a white flour in his description of the quarry of La Pila de Casares (see: CA-9), (Martínez y Delgado 1875: 129).

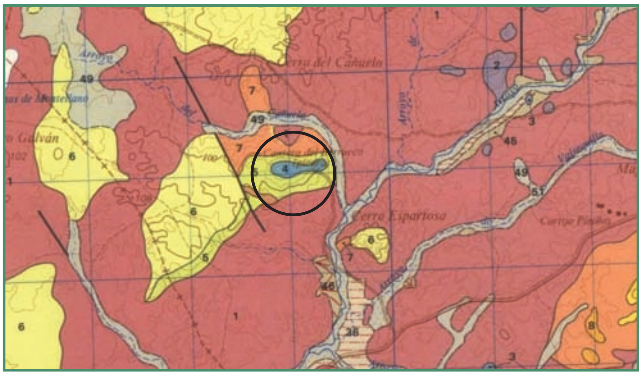
Rock type: Dolomite or limestone (Geological Map 1069, Chiclana de la Frontera, 1983). This is compatible with the description by Madoz that records a hard white rock (Madoz 1846, Vol. 4, 290).

View from the east of the emptied interior of the Berrueco mountain.

View of a working area on the northeastern edge of the mountain. There is, however, no evidence of millstone extraction in this sector.

View of the modern industrial installations on the eastern slope.

Limestone millstone in the town hall of the city of Medina Sidonia. This upper stone (Ø: 1,10m), possibly from the quarry of El Berrueco, equipped a windmill or tahona *in Medina Sidonia, a city perched on the top of a mountain without sources of running water to power watermill.*



Extract from geological map 1069 (IGME). The Berrueco quarry is a unit of dolomites and limestone (blue) surrounded by a unit of loamish limestones and white loams (yellow).

Source

Archive of Vejer de la Frontera: http://www.patrimoniojandalitoral.es/f_vai_8.htm [accessed February 12,2013].

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CA-9 Medina Sidonia

Pila de Casares

Latitude: 36º 27′ 4.89″ N
Longitude: 6º 2′ 20.30″ W
Altitude: 70-100 m

View from the northwest of the quarry of La Pila, now a vast exploitation site of limestone for lime.

Location: The quarry of La Pila de Casares is on a low mound about 5 km southeast of Medina Sidonia. It is now a vast exploitation for construction material.

Source: The site is noted in a local history of Medina Sidonia penned by a priest in the late 18th century (Martínez y Delgado 1875). The work was only published about a century after his death. This places the events he described toward the end of the 18th century. This site is not mentioned by any other 19th-century geographer (e.g. Madoz.).

The quarry: The present industrial activity at this site has probably obliterated all traces of the ancient workings. Unfortunately the site is fenced off and impossible to survey. A local resident informed me that a millstone, now vanished, once decorated the entrance of the industrial site.

Product and quantification: Martínez y Delgado's history specifies that millstones for "*molinos y atahonas*" (mills and animal-driven mills) were manufactured at this site (1875: 129). The author, unfortunately, does not designate if there are differences between the two types of millstones. Quantification of the production remains unknown.

Dating: The account of Martínez y Delgado places production toward the end of the 18th century.

Rock type: Dolomites and limestones or sandy limestones (Geological Map 1069, Chiclana de la Frontera, 1983).

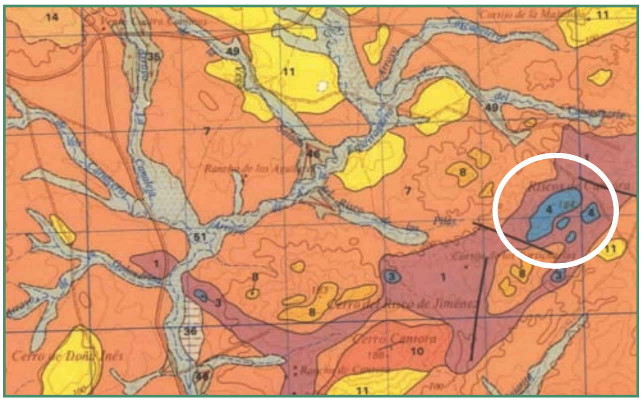
Bread: Martínez y Delgado provides rare insight into the quality of the rock and its influence on the bread: "This rock is not as white as that of the Berrueco, but it is sharper and grinds better ... and although it yields more flour from the same proportion of grain, the flour is darker and the bread is somewhat browner (Martínez y Delgado 1875: 129). The allusion is to nearby millstone quarry of El Berrueco, 15 km west (see CA-8).

Views of the modern industrial exploitation.

Orthophoto of the modern industrial exploitation (SIGPAC).

"Esta piedra no es tan blanca como la de Berrueco, pero es más cortante y muele mejor… y porque aunque saca más harina de igual porción de trigo, sale prieta y queda el pan algo moreno."

(from Martínez y Delgado 1875: 129).



Extract from geological map 1069 (IGME). The quarry is in the dolomite and limestone unit (blue) surrounded by a unit of clays and sandstones (purple).

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CA-10 Alcalá de los Gazules

Peña Arpada

Latitude: 36°30'02.07 " N
Longitude: 5°47'47.24" W
Altitude: c. 200 m

View from the south of the summit of the Peña Harpada mountain.

Orthophoto of the Peña Harpada mound (SIGPAC).

Location: *Peña Arpada*, as its name *peña* (rock or crag) suggests, is a conical elevation with, at its peak, a rugged karstic outcrop. The site is just off the main road between the towns of Paterna de Ribera and Alcalá de los Gazules. It is a biotope for a particular type of flower and place of interest for both ornithologists and rock climbers.

Sources: Madoz, in his description of the productions of the Municipality of Alcalá de los Gazules, identifies the millstones quarry for flour mills at "*Peña-Jarpa*" (Madoz 1845, Vol. 1: 376).

A very recent survey of the mound by a multidisciplinary research team (Giles *et al*. 2011) certifies the millstone production and brings to attention a neighbouring outcrop of ophite-dolerite at the base of the hill (the summit of a volcanic dyke) exploited since prehistoric times for stone pounders and possibly rubbers (*manos*) used with saddle querns (Giles *et al*. 2011: 117-118).

The quarry: Due to the limited size of the crag (less than 5000 m2), the quarry is not extensive. Extraction took place on at least three different levels. On the two lower levels, one can distinguish true extractive bench work on several tiers. At the upper level, near the summit (difficult to attain), several extractions took place on vertical planes. This suggests that the rock was sufficiently compact and homogeneous.

At the lower level, on the same plane as the Medieval features, there is an area of about 100 m2 with an unfinished millstone in its centre and flanked by extraction hollows. This area could have been a workshop to fashion the millstones.

It is also conceivable that millstones were hewn from blocks that were naturally detached or loosely connected with the bedrock. In this case, these extractions would have left little or no trace.

Products and quantification: There are several unfinished or broken millstones strewn about the site. One, with a pierced eye, is 1,27 m in diameter and 50 cm thick. Other fragments are comparable size. At least two cylinders, more than a metre in diameter and almost a metre thick, could be oil rollers. Because of the difficult access, the number of extractions is difficult to quantify. From the space available we estimate the number to have been between 50 and 100.

Techniques: In general, tool marks are poorly visible. In one sector pick trenching is visible.

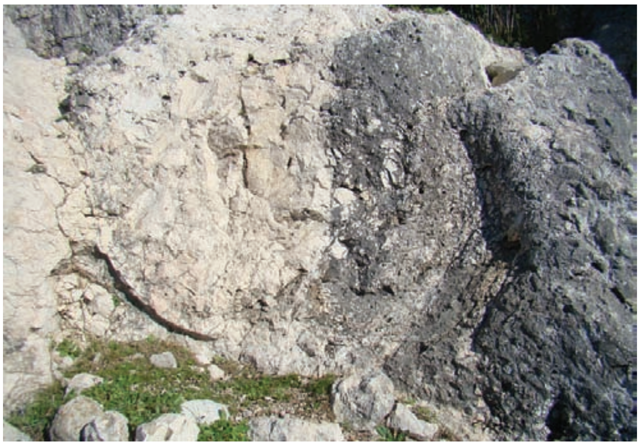
Transport and distribution: Lowering the heavy millstones through the rugged outcrop and down the slope would have been a complicated task. Once at the foot of the mound, the cylinders would have been ferried by cart along the nearby road linking Paterna to Alcalá de los Gazules.

Dwelling: There are features of either a watchtower or fortification on the top of this hill (Giles *et al*. 2011). These could have served as a refuge for the quarrymen.

Dating: Based on the Madoz text, the quarry dates at least to the first half of the 19th century. From the size of the extractions, work could have taken place since Medieval times. The pounder (ophite-dolerite) exploitation, at the base of the mountain, is presumably Prehistoric or Protohistoric.

Rock type: Dolomites and limestones (Geological Map 1063, Algar, 1984) for millstones. Ophites (dolerite) for prehistoric pounders.

View of an unfinished millstone in a space that was probably a workshop.



A vertical hollow is toward the top of the site.

Examples of horizontal extraction hollows in the lower levels of the quarry.


View of an unfinished millstone with a pierced eye.


Examples of fragments of millstones.


Examples of abandoned thick cylinders, possibly oil rollers.

Feature of a Medieval defensive structure or observation post. This old construction was probably used as a refuge for the millstone makers.

Extract from geological map 1063 (IGME). The quarry is in an isolated limestone and dolomite unit (blue).

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Acknowledgements

I thank Antonio Manuel de la VEGA DURAN for leading me to the site.

CA-11 Ubrique

Salto de la Mora

Latitude: 36º 41′ 16.02″ N
Longitude: 5º 26′ 49.65″ W
Altitude: 580 m

View from the town of Ubrique of the Salto de la Mora mountain (photograph by Manuel Cabello Izquierdo).

Circular hollows toward the summit of the Salto de la Mora mountain (photograph by Manuel Cabello Izquierdo).

Location: Ubrique is a town in the mountains of Grazalema. It is known traditionally for its leather products. The quarry is toward the summit of the Salto de la Mora Mountain, just north of Ubrique, inside the ancient walls of the Roman settlement of *Ocuri*.

Sources: The site is identified through the internet blog of Manuel Cabello and Ester Izquierdo. We have not identified any mention of the site in old text. Whetstone production, however, is recorded (García de la Leña 1789: 106-107; Madoz 146, Vol. 5: 140).

The quarry: The authors of the internet blog label the features "*cunas*" (nests) and interpret them either as basins to collect rainwater, a type of feature known in southern Spain, or millstone hollows. From the photographs, the site appears to be a pocket quarry.

Techniques: Multiple diagonal marks indicating pick work are clearly visible on the quarry faces.

Product and quantification: From the photographs the millstones seem to be about a metre in diameter. The authors of the blog do not indicate the number of extractions.

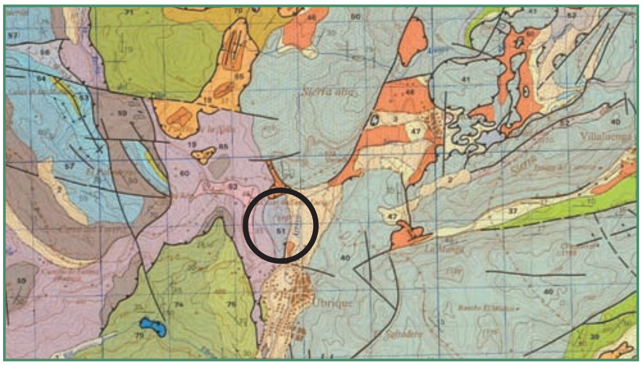
Transport and distribution: Owing to the difficult access of the site, production was probably limited to the local sphere.

Dating: Although the site is inside the ancient settlement of *Ocuri*, it is not Roman. From the size of the cylinders, it was probably exploited somewhere between Medieval and Contemporary times.

Rock type: Dolomite (Geological map 1050, Ubrique, 1980).

Detail of a circular hollow (photograph by Manuel Cabello).

Detail of an abandoned cylinder (photograph by Jesús Ortíz).



Extract from geological map 1050 (IGME). The quarry is in the dolomite unit (blue, no. 51).

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CA-12 Benaocaz

El Esparragal

Latitude: 36º 41′ 54.92″ N
Longitude: 5º 26′ 50.80″ W
Altitude: c.. 570 m

View from the southeast of the El Esparragal hill (photograph by Leandro Cabello).

Location and source: The Esparragal quarry is in the Grazalema Mountains on a conical mound about 2 km north of Ubrique beside the road leading to Benaocaz (see CA-12). The site is identified in the internet blog by Manuel Cabello and Ester Izquierdo of Ubrique.

The quarry: The hollow seen in one photograph indicates a true extractive site, probably a pocket quarry.

Products and quantification: We do not know the exact size of the millstones or the number produced on the site. From the photographs they appear to be around 1 m.

Transport and distribution: The author of the blog records an anecdote, related to him by local resident, on how a millstone was transported from this site to Ubrique. Juan Pino met three people on the road to Benaocaz who were transporting a millstone from the meadow along a path beside the Laguna. Intrigued as to how the heavy millstone was moved along the stone-paved road, the men replied that they inserted a beam through the hole permitting two of them to hold the millstone upright while the third pushed the millstone forward or slowed it down, depending on the terrain.

Dwelling: The authors of the blog say that a *covacha* (hovel) in the area could have provided shelter for the quarrymen. Their permanent residence was probably in Ubrique, a few minutes downhill from the site.

Dating: The anecdote indicates the quarry was active in the first half of the 20th century.

Rock type: Limestones or oolites (Geological Map 1050, Ubrique 1980). This rock is also compatible with the material necessary for a nearby lime kiln reported in the blog.

Abandoned unfinished millstone (photograph by L. Cabello).

Circular hollow toward the summit of the Salto de la Mora mountain (photograph by L. Cabello).

Stone covacha *(hovel) that could have provided cover for the millstone makers (photograph by L. Cabello).*

A anecdote about how to transport a millstone

"Como anécdota [Juan Pino] recordaba que un día se encontró en la carretera de Benaocaz más arriba de Santa Lucía a tres personas que traían una piedra de molino desde la zona del hondón y habían pasado por una vereda que esta junto a La Laguna. Al preguntarle intrigado como la trasladaban, teniendo en cuenta que era un camino empedrado y el peso, la respuesta: Pues le habían puesto una viga en el agujero y la sujetaban entre dos, el tercero la empujaba o la frenaba según el terreno".

(from Leandro Cabello in the blog of M. Cabello and E. Izquierdo, October 27, 2010).

Extract from geological map 1050 (IGME). The quarry is in a unit of limestone or oolite.

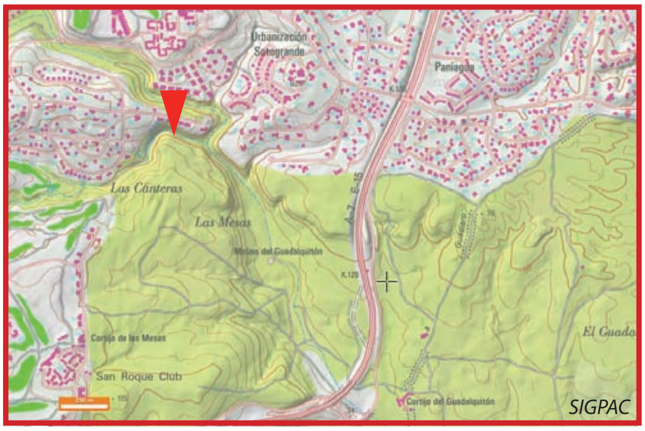
Source

Leandro CABELLO, ¿Como se puede trasladar una piedra de molino? in the blog of M. CABELLO and E. IZQUIERDO, October 27, 2010: http://manuelcabelloyesperanzaizquierdo.blogspot.com.es/2010/10/como-se-puede-trasladar-una-piedra-de.html [accessed November 6, 2012].

CA-13 San Roque

Las Canteras - Guadalquitón

Latitude: 36º 16’ 28.71”N
Longitude: 5º 19’ 48.23”W
Altitude: c. 40-70 m



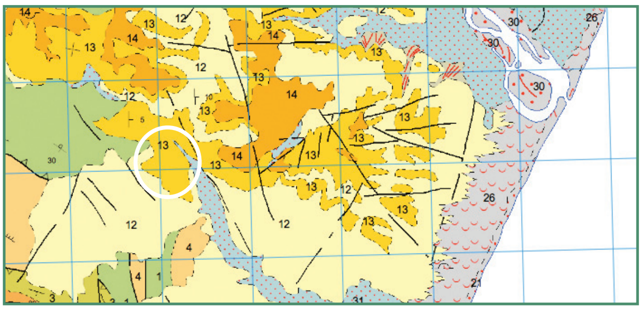
Location: The millstone quarry of *Las Canteras* is in the Guadalquitón basin along a stream bearing the same name (*Arroyo de las Canteras*). It is about 10 km northeast of the city of San Roque and 3 km from the Mediterranean coast. Most of this area has in the last few years been built over.

Sources: The site is mentioned briefly in several historical articles by Benoso Santos.

Toponymy: *Las Canteras* (the quarries) is a place name frequently associated with millstone extraction.

The quarry: The exact location of the site escapes us. If it is still preserved, it could be along the stream in the tree line between the golf course and the houses.

Products and quantification: Benoso notes that these millstones, known popularly as *guadalquitonas*, were the main source of local millstones (Beneroso 2011, 499, note 18), suggesting a modest production.



Extract from geological map 1075 (IGME). The quarry is in a unit of lumachella limestone (orange no. 13).

Transport and distribution: Local production.

Dating: According to Beneroso, the quarry was in use as late as the 1960s (Beneroso 2011: 498, note 18). There is no data concerning its earlier use.

Rock type: Lumachella limestone (Geological Map 1075, San Roque, 1980).

Abandoned millstone. Extract from Beneroso 2007:15 (photograph by Manuel L. Pérez Serralbo).

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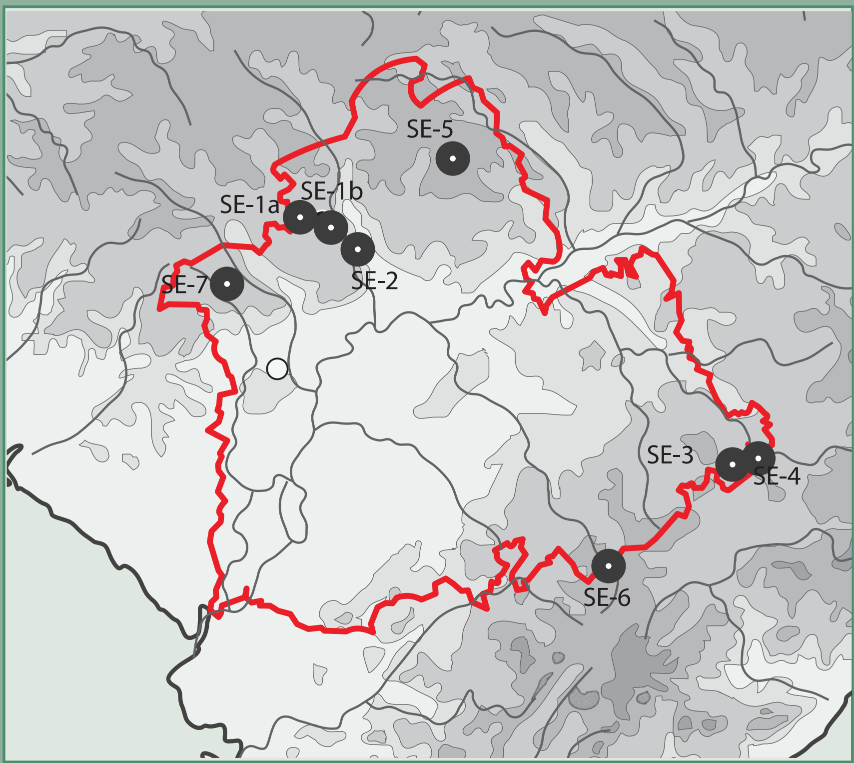
ANDALUSIA
SEVILLE (SE)



SE-1a Almadén de la Plata

Arroyo de las Calzadillas 1

Latitude: 37º 51′ 37.54″ N
Longitude: 6º 1′ 2.45″ W
Altitude: 260-270 m

View from the south of the quern quarry along the bed of the ravine uphill from the Calzadilla stream.

Location and generalities: The Calzadilla quern quarry is 6 km east of Almadén de la Plata near the Calzadilla stream. The site is in the Andalusian Natural Park of the Sierra Norte, a region with great geological diversity that was recently selected as a member of the network of European Geoparks.

Source: The quarry was discovered by workmen clearing brush for forest fire prevention. They originally interpreted the circular extraction hollows as "jellyfish fossils". The quarry became known to the public through a television interview with the archaeologist Miguel Ángel Vargas (interview available on youtube, see sources). Since then it has been presented in an article submitted to the proceedings of the Bergen Colloquium (Anderson *et al.*, forthcoming)

Toponymy: The place name "*Calzadilla*" is the diminutive of "*calzada*", meaning road, and is associated with a commercial thoroughfare following the waterway that dates to Antiquity.

The quarry: The largest sector of this site is a shallow surface quern quarry in the bed of a lateral ravine about 100 m uphill from the stream. Depending on the time of the year, some extractions are under water. In the lower part of the ravine there are a series of isolated or clustered surface quern extractions. Other hollows are possibly hidden under the topsoil.

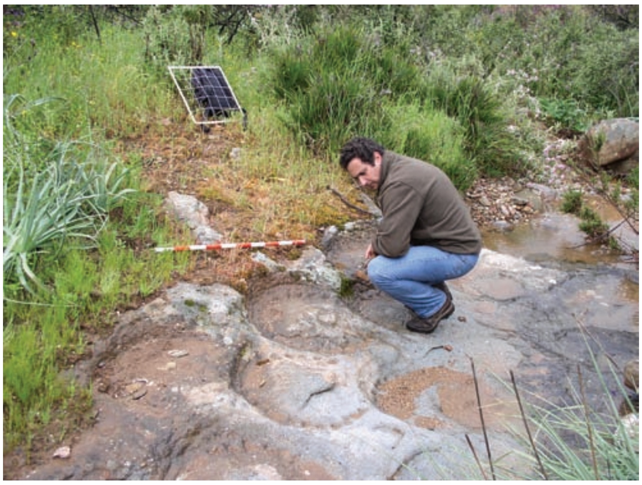
Techniques: Extraction was restricted to outcrops where the sandstone contained small homogeneous pebbles. The outcrops with larger pebbles (1 cm) were avoided. Extreme weathering of the rock surface renders the extraction techniques difficult to define. From what we have observed, a circular trench was first cut around the cylinder with a pick following the technique of three "passes". To split the cylinder from the bedrock, the quarryman pierced up to 30 small holes at regular intervals (every 6-7 cm) along the base. These are directed to the centre and resemble the dial of a clock. We suppose the impacts producing these holes were sufficient to split the cylinder and wedging with iron wedges or wooden pegs was not necessary.

Products and quantification: The cylinders correspond systematically to discoidal rotary querns measuring 50 cm in diameter. There is no deviation in size indicating a standardised product.

Transport and distribution: The nearby *Calzadillas* road facilitated transport. From the number extracted, less than 50, we doubt that the product was commercialised over very long distances

Dating: This type of site is rare in the Iberian Peninsula. Based on our research on querns, these discoidal stones are larger and thinner than their earlier Iron Age and Roman counterparts. They are also notably thinner than Contemporary animal fodder querns. They therefore must date to Medieval times, possibly during the Islamic domination.

Rock type: Conglomerate (Geological map 919, Almadén de la Plata, 1972). In the words of the geologist Alberto Gil: "The rock is a brownish, coarse micro-conglomerate containing rounded clasts (<1 cm). The Viar basin is a continental basin from the Lower Permian Age (300 million years) to presumably the Lower Triassic Age (235 million years). The deposits are fluviatile conglomerates constituted of a mixture of local screes and braided conglomeratic sandstones, red beds, and acidic volcaniclastic deposits."



View of the quern quarry with the shallow surface extraction hollows.

Detail of the extraction hollows corresponding to rotary querns measuring about 50 cm in diameter.

Detail of a small group of quern extractions downhill from the larger extraction sector.

Detail of a partly covered, unfinished cylinder.

Detail of the micro-conglomerate.

Extract from geological map 919 (IGME). The quarry is in a unit of conglomerate (brown with circles) and not the spilites, altered basalt units (in blue).

Source

Television interview with Miguel Ángel VARGAS: http://www.canalsur.es/portal_rtva/web/noticia/id/112752/portada/hallada_una_cantera_de_epoca_romana_en_almaden [accessed November 12, 2011].

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VARGAS, Miguel Ángel, ANDERSON, Timothy, GIL TOJA, Alberto and PÉREZ de GUZMÁN PUJA, Rafael. Millstone and Quern Quarries in the Viar River Basin, Province of Seville, Spain. Poster presented at the colloquium "Seen Through a Millstone" Bergen, Norway, Oct. 19-21, 201

Acknowledgments

I thank the archaeologist Miguel Ángel VARGAS (PRODETUR) and the geologist Alberto GIL TOJA (TRAGSA) for guiding me to the site.

SE-1b Almaden de la Plata

Arroyo de las Calzadillas 2

Latitude: 37º 51’31.99” N
Longitude: 6º 1’5.66” W
Altitude: 250 m

View from the east of an outcrop of conglomerate in the heart of the Calzadillas stream with both quern and small millstone extraction hollows.

Location and generalities: This quern and millstone quarry is directly in the bed of the *Calzadilla* stream, about a hundred metres from the uphill quern extraction sector (see SE-1a). Here the dominant product is the medium-sized cylinder (80 cm) destined for either watermills or animal-driven mills.

The quarry: The site is a shallow surface quarry. It comprises a series of discontiguous outcrops spread along the riverbed over about 150 m. In winter, during the rainy season, the extractions are covered by water. This accounts for the extreme weathering of their surface that has erased most of the tool marks.

Product, quantification and dating: The extraction hollows correspond to millstones measuring about 80 cm in diameter, a size that points to a very old exploitation probably contemporary to the querns (Medieval). The total production is modest, probably fewer than 50. The extraction techniques of both querns and the millstones are identical, suggesting that they are contemporary.

Rock type: Conglomerate (see SE-1).

Examples of extraction hollows corresponding to small millstones measuring approximately 80 cm in diameter.

Examples of extraction hollows corresponding to querns measuring approximately 50 cm in diameter (all photographs by T. Anderson except 3-4 by Alberto Gil Toja).

Detail of the conglomerate (photograph by Alberto Gil Toja

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VARGAS, Miguel Ángel, ANDERSON, Timothy, GIL TOJA, Alberto and PÉREZ de GUZMÁN PUJA, Rafael. Millstone and Quern Quarries in the Viar River Basin, Province of Seville, Spain. Poster presented at the colloquium "Seen Through a Millstone" Bergen, Norway, Oct. 19-21, 201. Publication in preparation.

Acknowledgments

I thank the archaeologist Miguel Ángel VARGAS (PRODETUR), the geologist Alberto GIL TOJA and the biologist Rafael PÉREZ de GUZMÁN PUJA (TRAGSA) for guiding me to the site.

SE-2 El Pedroso

El Castillejo

Latitude: 37º 46' 26.02"N
Longitude: 5º 52' 27.33""W
Altitude: 95 m

View from the south of the sandstone outcrop bearing the quern extractions.

Location: The quarry of *Castillejos* is in the Sierra Norte National Park in the Viar River Valley about 15 km southwest of the *Calzadillas* (SE-1). Since it is on private land and behind a fence, it is not possible to ascertain if the extractions are isolated or part of a larger exploitation.

The quarry: This shallow surface quarry comprises only two small, extremely weathered hollows.

Products and quantification: The cylinders correspond to handquerns measuring 40 cm in diameter.

Transport and distribution: There are no obstacles to distribute querns from this site.

Dating: Although the diameter of 40 cm suggests a Roman date, the modest width points to the Middle Ages.

Rock type: Conglomerate (Geological map, 940, Castilblanco de los Arroyos, 1975).

Detail of the two extraction hollows.

Extract from geological map 940 (IGME). The quarry is in the heart of a conglomerate unit (brown).

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Acknowledgments

I thank the archaeologist Miguel Ángel VARGAS (PRODETUR), the geologist Alberto GIL TOJA and the biologist Rafael PÉREZ de GUZMÁN PUJA (TRAGSA) for guiding me to the site.

SE-3 Lora de Estepa

El Hacho

Latitude: 37º 17' 56.11"N
Longitude: 4º 50' 18.44"W
Altitude: 390-400 m

View from the north of the extremity of Hacho Mountain. The millstone quarry is on the slope in the oak forest above the olive orchard.

Location: This site covers a surface of about half a hectare on the slope at the northern extremity of the Sierra del Hacho, beside the road linking the town of La Salada to the city of Estepa.

Source: According Madoz, the material is a "piedra *bravía, blanca y aprópósito para molinos de harina*" (coarse, white rock appropriate for flour mills) (Madoz 1847, Vol. 7: 690).

The quarry: Since the outcrop is in a fractured, karstic terrain, the site is organised in a series of small pockets measuring in each case less than 100 m2. Each pocket has its corresponding spoil heap.

Techniques: From the few tool marks visible, we deduce that cylinders were cut directly into the bedrock following horizontal planes resulting in circular hollows. The hollows are at times superimposed on up to three levels. It is also possible that part of the production was scored from detached blocks. The rough cylinders were fashioned beside the extraction zones, propped up on rocks that served as pedestals. These fashioning workshops can at times be made out, despite the absence of a cylinder, from a group of pedestal rocks surrounded by an "aura" of finer working debris, cut off from the cylinder while fashioning.

Each extraction workshop is accompanied by a mound or cordon of working debris. The spoil, always downhill, appears at times to have backfilled earlier extraction sectors.

Products and quantification: The cylinders measure between 1,00 and 1,20 m in diameter. A very thick example might be for an oil roller. A local resident related that most of the better preserved cylinders now decorate the gardens of private residences. Production here is quantified roughly to between 50 and 100 cylinders.

Transport and distribution: Export of the product would have been facilitated by the nearby road linking La Salada and Estepa. Production was probably local, or possibly slightly beyond.

Dating: The Madoz reference places the site toward the middle of the 19th century.

Rock type: Limestone (Geological map 1006, Benamejí, 1983). Madoz specifies that the quarry exploited a white, "*bravia*" (meaning rough or coarse) rock.

General views and details of different pocket extraction workshops.




Examples of cordons of working debris in front of the workshops.




Examples of abandoned millstones measuring between 1,00 m and 1,20 m in diameter. The cylinders are at times propped on rocks (pedestals) to facilitate their fashioning.

Extract from geological map 1006 (IGME). The quarry is at the northern fringe of the a limestone (blue) outcrop.

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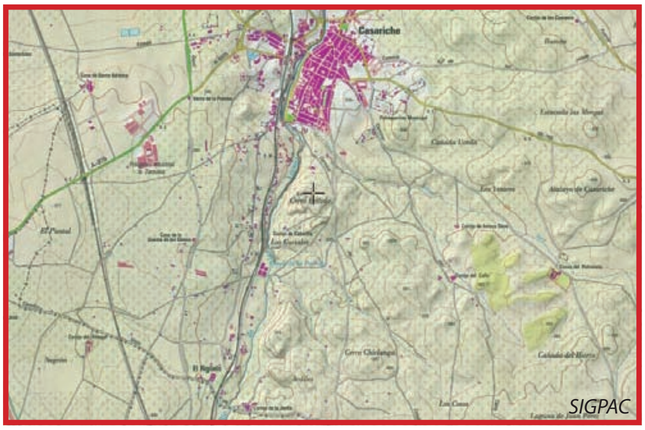
SE-4 Casariche

Cerro Bellido

Latitude: 37° 16′ 57.20″ N
Longitude: 4° 45′ 44.36 ″W
Altitude: 350-358 m



View from the north of the Cerro Bellido quarry.

Location and generalities: The Roman Cerro Bellido drum column quarry is on a hillock south of Casariche. This one of the best preserved and most spectacular extraction sites of southern Spain and one of the few that is officially protected and provided with paths and explanation panels.

Although not technically a millstone quarry, it is retained in this catalogue because it is presumably the source of recycled millstones along the nearby Yeguas River. We cannot be excluded that abandoned Roman column drums were subsequently used as millstones, especially since the rock is a hard, porous limestone.

A second quarry, *La Canteruela* (meaning small quarry), located on a hill 1 km to the northeast, is identical to that of Cerro Bellido. Unfortunately, this ″twin″ quarry did not benefit from the attention granted to Cerro Bellido and is now a landfill.

The quarry: The quarry is a deep open-air pit where large cylinders were scored directly from a massive limestone stratum resulting in a great number of tubular quarry faces.

Extraction marks are very well conserved. Because of the significant width of certain cylinders, up to about a metre, the parallel pick lines remaining on

View of the Cerro Bellido quarry from the west.

View of the Cerro Bellido quarry from the east.

the quarry front are but "arc-shaped", revealing the semi-circular trajectory of the pick used to cut the deep circular trench.

A single large wedge hole (about 25 cm long) at the base of one of the abandoned cylinders is indicative of the technique to split the cylinders from the bedrock.

Products and quantification: There is no indication that the quarry produced anything but cylindrical column drums measuring about 1 metre in diameter and 1 metre thick. Hundreds were extracted from this site.

Transport and distribution: The drums are reputed to have been transported to the Roman city of *Corduba* (Córdoba) for use in monumental buildings.

Dating: Roman. There is no evidence of more recent extractions.

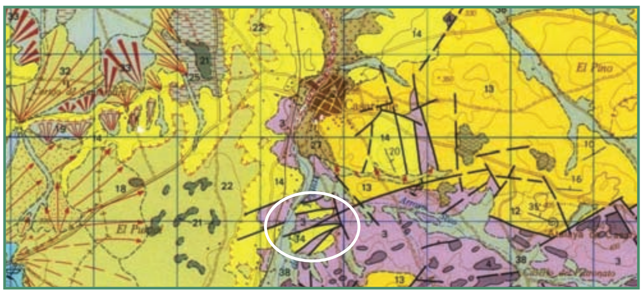
Rock type: Rough, porous limestone (Geological map 988, Puente-Geníl, 1988).

Detail of a tubular quarry face with parallel tool marks revealing an arc-shaped trajectory of the pick used to cut the circular trench.

Orthophoto of the Cerro Bellido quarry (SIGPAC).

Examples of abandoned Roman column drums. The example on the lower left has a wedge hole. This type of drum would have easily been recycled into millstones.

The "twin" quarry Las Canteruelas, 1 km northeast of Cerro Bellido, which is now a landfill (photograph by Franciso Estepa, http://historiadecasariche.blogspot.com.es/p/23-cerro-bellido.html*).*



Extract from geological map 988 (IGME). The limestone outcrops in the circle (in yellow) correspond to a Roman exploitation.

Sources

http://rutadeltempranillo.org/index.php?page=86 [accessed Octorber 14, 2012].

Francisco ESTEPA: http://historiadecasariche.blogspot.com.es/p/23-cerro-bellido.html [accessed Octorber 14, 2012].

Acknowledgment

I thank F. ESTEPA, local historian, for information about this site.

SE-5 Alanís

Location and generalities: Alanís is a large municipality (280 km2) along the northern border of the Province of Seville toward the edge of the Sierra Morena mountains. Our research of toponyms related to millstone work and our inquiries among local authorities have not yielded any further information. The rock type also remains unknown.

Source: From the standpoint of rock extraction, Alanís is known since the 18th century in several geographical dictionaries for its whetstones for sharpening razors. Beside the whetstone production, Madoz also briefly mentions millstone workings (1845, Vol. 1: 190). This author, unfortunately, throws no light on any particular aspect of the site or its location.

Dating: Middle of the 19th century.

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SE-6 Villanueva de San Juan

Location: Villanueva de San Juan is a small municipality (34 km2) in the rolling hills north of the Sierra de la Rabitilla in the southeastern area of the Province of Seville bordering the Provinces of Cádiz and Málaga.

Source: The "quarry" is described by Madoz as follows: "...there is a millstone quarry that is not exploited for lack of a road" (Madoz 1850, Vol. 16: 207). Madoz goes on to specify that all the roads in the municipality are "local" and "bad". He provides no clue as to its location and leaves us with the doubt if there was ever any site exploited as a quarry. In any case we have not identified any place name indicative of millstone production.

Transport: Madoz's text highlights the importance of a network of roads to facilitate the trade of millstones in isolated regions.

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SE-7 Gerena district

Location and generalities: Gerena is in the heart of in a granite district north of Seville at the foot of the Sierra Morena. It has a long tradition of working granite. Quarries in this area in Antiquity presumably supplied granite for constructions in the Roman city of *Italica* (12 km away). A small museum (*Museo del Cantero*), dedicated to the legacy of stonework (cobblestones, building stones, oil rollers, rotary querns), was inaugurated in Gerena in 2007.

Gerena is especially well known for its cone-shaped rollers for the olive oil industry, one of the main industries of Andalusia (Madoz 1847, Vol. 8: 348). Examples of these rollers can be seen in a series of old photographs presented in this catalogue. Although there is no evidence of the production of millstones for flour mills, it is hard to conceive that millstone cylinders were not produced in and around Gerena. Rotary handquerns, presumably from local quarries, for example, are found in the local museum. These appear to date to Roman times. Lucas Acuña, author of a history of Gerena (2004), confirms the presence of granite millstones in local flour mills.

Toponymy: Several place names in and around Gerena are related to rocks and rock work (*Las Canteras*, *Las Perreras*, *El Berrocal*). There is no evidence any toponym specifically related to millstone production.

One place names, *La Rodadera*, is in the middle of town, and part is conserved in a park. The word "*rodadera*" is a geographical term that alludes to a sharply inclined rock outcrop where rocks can be naturally detached.

The quarries: The quarries of Gerena are large, deep open air pits. Blocks were detached before being fashioned. Since quarry floors attained the water table, water had to be constantly pumped out. This explains why some of these sites today are either filled with water, or backfilled, as in the case of the *Tajo of Pepe Luis*. Old photographs (Acuña 2004) offer an impression of the former working conditions, as well as the rugged aspect of the quarrymen.

Orthophoto indicating the location of the exploitations inside Gerena. The pits to the northeast (Fuente Santa quarry) are now filled with water. The other two quarries are backfilled. The Tajo of Pepe Luis *(centre) is now a heliport, and* Los Rodaderos *(bottom left) is integrated into an urban park (SIGPAC).*

Products and quantification: Products included conical oil rollers, cobblestones, and diverse building materials such as columns for buildings in both Seville and Cádiz (blog of G. Herdugo). In spite of the lack of evidence, it is perfectly plausible that cylindrical millstones, much easier to fashion (due to their more simple form) than conical oil rollers, were also produced in the area. Lucas Acuña, author of a pictoral history of Gerena (2004), confirms the presence of granite millstones in local watermills.

Transport and distribution: Genera is one of the few quarry districts that benefitted from a rail link (6,8 km long) built in 1911 to connect its granite quarries to the line between the mining district of Aznalcóllar and San Juan de Aznalfarache on the

Guadalquivir River near Seville (33 km). Several old photographs show rock products being loaded onto a train at Gerena (website of El Ferrocarril De Aznalcóllar - Guadalquivir). Once again, there are no photographs indicating millstone transport.

Dating: It is conceivable that this district produced millstones from Roman until Contemporary times.

Rock type: Granite (Geological map 962, Alcalá del Río, 1972).The Granite of Genera is reputed to have been particularly hard. According to oral information, this hardness, ironically, was the cause of the demise of its quarries because it became too costly to continue exploiting them.

Views of the pit quarries Tajo de Barriales y Tajo de Los Meino (photograph by L. Acuña Carabantes).

Views of the backfilled pit quarry called the Tajo de Pepe Luis *(Kini SANTOS: http://gerenaverde.blogspot.com.es/2010/10/el-pgou-desprotege-las-canteras-reduce_26.html).*

View of the deep pit quarry called the Tajo de Pepe Luis *in 1950s (from Acuña Carabantes 2004).*

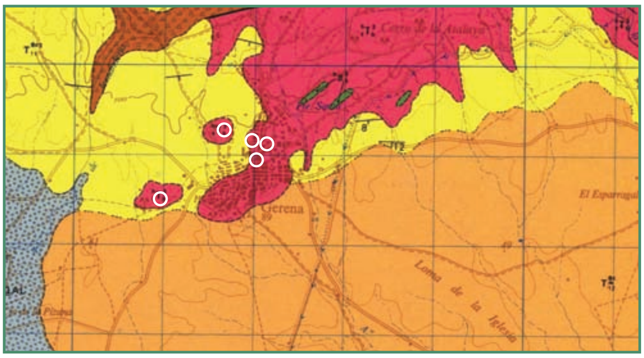
View of the fashioning conical oil rollers in the area of Gerena.(from Acuña Carabantes 2004).

Detail of a working area of a quarry in Gerena. Among the construction material, there are several conical oil rollers (photograph from Acuña Carabantes 2004).

View of the rail station of Gerena in service since 1911. Granite blocks were loaded on the wagons. Conical oil rollers (and millstones?) were certainly also transported by rail (from Website El Ferrocarril De Aznalcóllar - Guadalquivir).

Photograph from the 1920s of Gerena quarrymen working building material. One appears to be removing a shard from the eye of the other. A boy is sitting in the background (left) (photograph from Acuña Carabantes 2004).

Example of a granite millstone in a local watermill. The stone comes, presumably, from a local quarry (photograph by Acuña Carabantes).



Extract from geological map 962 (IGME). The quarries coincide with the plutonic (granite) outcrops in red.

Sources

Kini SANTOS: http://gerenaverde.blogspot.com.es/2010/10/el-pgou-desprotege-las-canteras-reduce_26.html [accessed October 15, 2012].

Gonzalo HERDUGO: http://gerenadiario.blogspot.com.es/2009/03/blog-post.html [accessed December 2, 2013].

El Ferrocarril De Aznalcóllar - Guadalquivir: http://www.portalaznalcollar.com/ferrocarril/ferrocarril.htm [accessed October 15, 2012].

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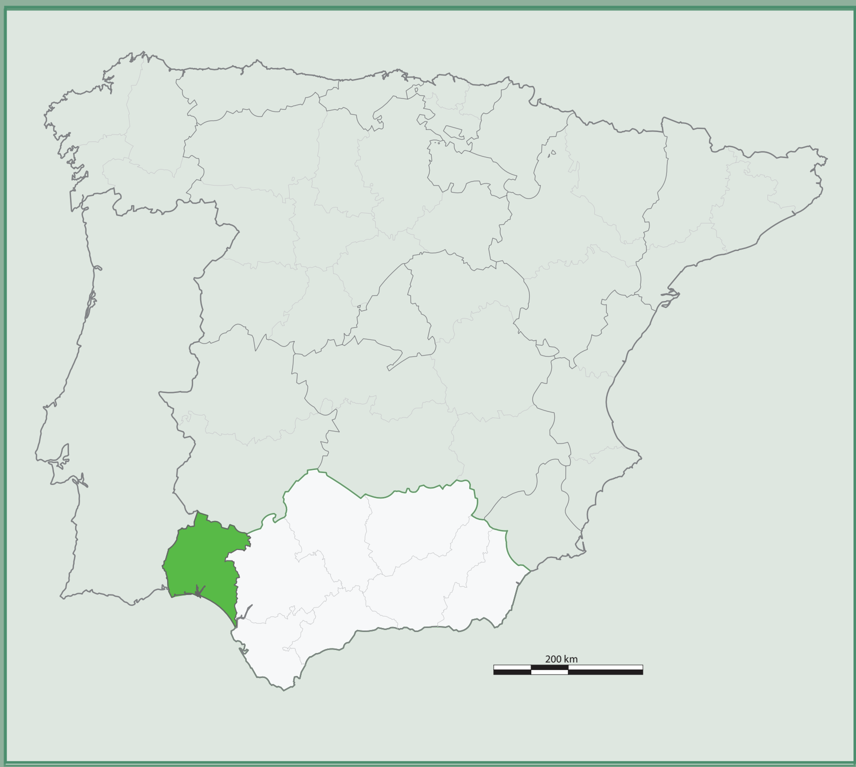
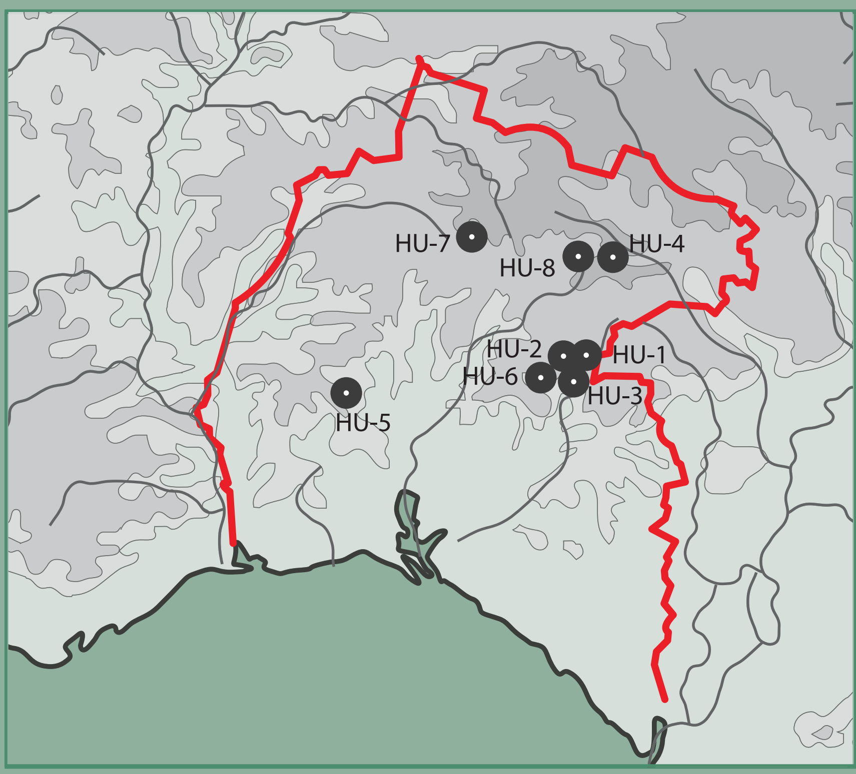
Acknowledgment

I thank J. SANTOS for his assistance. L. ACUÑA CARABANTE, historian and grandson of Pepe Luis (quarry owner), provided photographs and precious information.

ANDALUSIA

HUELVA (HU)





HU-1 El Campillo

Umbría del Hornillo

Latitude: 37º 41′56.87″N
Longitude: 6º 37′15.60″W
Altitude: C. 400 m

View of a sector of inclined schist surface blocks exploited for millstones (photograph by Alonso García Veiga).

Example of an abandoned vertical extraction. The lines on the edge of the millstone indicate that the cylinder was scored with a pick (photograph by Alonso García Veiga).

Location: The *Umbrío del Hornillo* quarry is 500 m east of El Campillo on a slope near the border with the Municipality of the Minas de Río Tinto, famous for its mining industry. The site is in a forest and partly covered by vegetation.

Source: The quarry is identified in the study of the watermills of the Odiel River by R. Gomez (2003: 85-86). Although divided into 3 sectors in the study, the site can be considered a homogeneous unit.

Toponymy: The term *umbrías* refers to a shady area while *hornillos* signifies a small oven. *Hornillos* can also mean the holes or cavities that were carved in mines to lodge powder for blasting. Although there is no evidence of blasting in this area, the term could possibly evoke the wedge holes carved to split cylinders from the rock.

The quarry and techniques: The site is spread over a surface of several hundred metres along a slope covered with a combination of large, loose surface blocks and large, highly inclined slabs. A sector to the south is now under a rubbish heap or destroyed by work related to a skeet shooting range. Most of the extractions took place on vertical or inclined planes following the rock's original natural bedding plane. At times trenches cut around the cylinders reveal linear pick marks.

Product, quantification and dating: According to A. García, the diameters of the cylinders vary between 1,10 and 1,26 m. This range suggest a dating ranging from Medieval to Contemporary times. The number of extractions is probably about 50.

Distribution: The sphere of distribution was probably local.

Rock type: The site straddles a unit of volcano-sedimentary flow, tuff and slate (light violet) and a unit of agglomerate of acidic schists and intermediate volcano-sedimentary flows (green) (Geological map 938, Nerva; 1978). The department of geology of the University of Huelva (Gomez 2003: 85-86) determined that the millstone rocks are 1) altered feldspar tuff, 2) greenish silicious chloritic tuff and 3) silicious chloritic tuff.

General view from the south of slope with the millstone quarry. The gigantic heap in the background is spoil from the Río Tinto exploitation.

View of the quarry landscape with numerous loose surface blocks.

Views of cylinders still attached to the rock mass.

Detail of the holes meant to lodge wedges to detach the cylinder (all photographs by Alonso García Veiga).

Details of vertical extraction hollows.

Detail of an extraction hollow.

Detail of a cylinder attached to the rock mass.

Detail of an abandoned, partially fashioned, cylinder.

Detail of an abandoned cylinder (all photographs by Alonso García Veiga).

Extract of the geological map 938 (IGME). The site straddles units of volcanic sedimentary flows, tuffs and schists (light violet) and conglomerates/schisty acid and intermediate volcano-sedimentary flows (green). The quarry exploited schists of the second unit.

Source

Alonso GARCÍA VEIGA. Canteras Medievales de El Campillo, Canteras Medievales de Piedras de Molino. Las Piedras Molares. http://alongarvi.blogspot.com.es/2009/11/canteras-medievales-de-el-campillo.html [accessed November 12, 2012].

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GÓMEZ RUIZ, Ricardo. *Molinos en el Río Odiel. Un Estudio de Arqueología Industrial en los Límites de El Andévalo*, 2003, 138 p.

Acknowledgements

I warmly thank Alonso GARCÍA VEIGA, the author of the photographs, for valuable information about this site.

HU-2 Linares de la Sierra

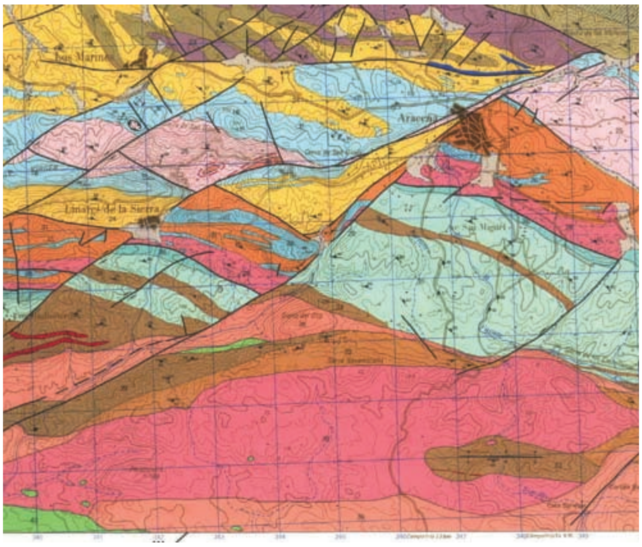
EL Prao de Abad I-II

Location and source: These quarries are identified in the study of the watermills along the Odiel River by R. Gomez (2003: 85-86). There is, nonetheless, confusion as to their location. They are reputed to be in the Municipality of Alájar. However, from our inquiries, they appear to be in the Municipality of Linares de la Sierra. In any case the site is somewhere in a mountainous area.

Product, quantification and dating: Millstones for watermills. Neither the sizes or the number of extractions are known. The date of these sites, according to the size of the millstones, ranges from Medieval to Contemporary times.

Distribution: From the little we can gather about this site, it must has served local mills.

Rock type: Biotite granite (Gómez 2003: 85-86). Analyses undertaken by the department of geology of the University of Huelva. Abad I has black crystals while Abad II is rose coloured.



Extracts from the geological map 917 (IGME) The site is probably to be found in the granite and porphyric granite units south of the Linares de la Sierra and Aracena (units 38 and 39, pink and reddish hues). The green unit can be excluded (gabro).

Source

Alonso GARCÍA VEIGA. Canteras Medievales de El Campillo, Canteras Medievales de Piedras de Molino. Las Piedras Molares. http://alongarvi.blogspot.com.es/2009/11/canteras-medievales-de-el-campillo.html [accessed November 12, 2012]. [accessed November 12, 2012].

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HU-3 Linares de la Sierra

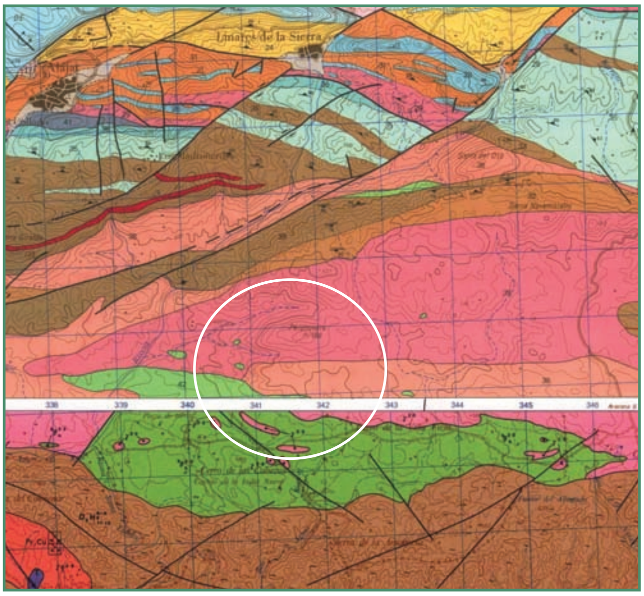
Las Malenas I-II

Location and sources: The quarries of *Las Malenas* are recorded in the study of the watermills along the Odiel River by R. Gomez (2003: 85-86). As in the case of the Prao del Abad (HU-2), we were not able to pinpoint the position of the site. Although reported in the Municipality of Alájar, it is probably, from our inquiries, in the neighbouring Municipality of Linares in the area of Los Indios.

Product and dating: Millstones for watermills. The date of these sites, according to the size of the millstones, ranges from Medieval to Contemporary times.

Distribution: There is no data indicating this is not more than quarry to supply millstones to local mills.

Rock type: White biotite granite. Analyses undertaken by the Department of Geology of the University of Huelva.



Extracts from the geological maps 917 and 938 (IGME) The site is probably to be found in the granite and porphyric granite units south of the town (units 38 and 39, pink and reddish hues). The green unit can be excluded (gabro).

Source

Alonso GARCÍA VEIGA. Canteras Medievales de El Campillo, Canteras Medievales de Piedras de Molino. Las Piedras Molares. http://alongarvi.blogspot.com.es/2009/11/canteras-medievales-de-el-campillo.html [accessed November 12, 2012].[accessed November 12, 2012].

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HU-4 Aracena

La Obra Pía

Latitude: 37º 49’ 34.38” N
Longitude: 6º 34’ 22.05” W
Altitude: c. 530 m

Location and Toponymy: The Obra Pía millstone quarry is about 10 km south of the city of Aracena near the *cortijo* or *coto* (farm house) with the same name in an area of rolling hills at the foot of Cantaelgallo Mountain.

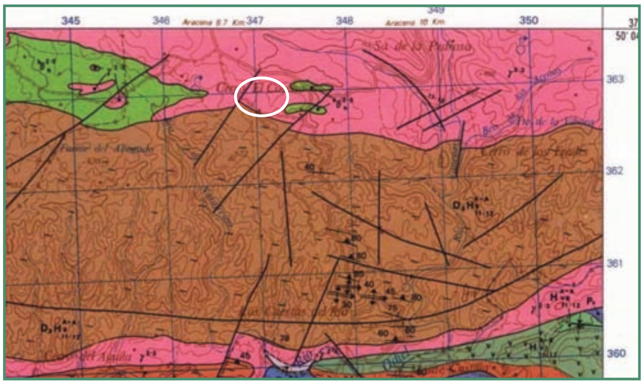
Sources: The quarry is recorded in the study of the watermills along the Odiel River (Gomez 2003: 85-86).

The quarry: According to R. Gómez, the site exploited surface blocs. Some of the larger blocks were exploited for more than one millstone (R. Gómez, pers. comm.).

Distribution: The production was probably destined for local watermills.

Product and dating: All of the millstones measure about 1 m in diameter. Their dating ranges from Medieval to Contemporary times.

Rock type: Granite or biotite granite. Geological map 938, Nerva, 1979. Altered granite according to analyses undertaken by the Department of Geology of the University of Huelva (Gómez 2003: 86).



Extract of the Geological map 938 (IGME). The quarry is in the reddish area (granites). The greenish outcrops to the east are gabros and the brownish areas to the south are schists or greywackes.

Source

Alonso GARCÍA VEIGA. Canteras Medievales de El Campillo, Canteras Medievales de Piedras de Molino. Las Piedras Molares. http://alongarvi.blogspot.com.es/2009/11/canteras-medievales-de-el-campillo.html [accessed November 12, 2012].[accessed November 12, 2012].

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Acknowledgements

I sincerely thank the historian Ricardo GÓMEZ RUIZ for information about this site.

HU-5 Puebla de Guzmán

Cerro del Águila

Latitude: 37º 36' 4.34" N
Longitude: 7º 12' 11.87" W
Altitude: 350-390 m

Old photograph of the rocky Cerro del Águila (photograph from http://www.pueblos-espana.org/andalucia/huelva/puebla+de+guzman/galeria-fotografica/.

Orthophoto of the Cerro del Águila (SIGPAC). Millstone exploitation probably took place on rocky northeastern face of the montain.

Location: The Cerro del Águila, also known as Virgen de la Peña, is a rocky hillock 4 km southeast of Puebla de Guzmán. It has a long tradition of human occupation since the Bronze Age and is now a Hermatige (Ermita de la Virgen de la Peña).

Sources: Millstone production at the outcrop is mentioned briefly in an article about the local windmills (Garrido 2001).

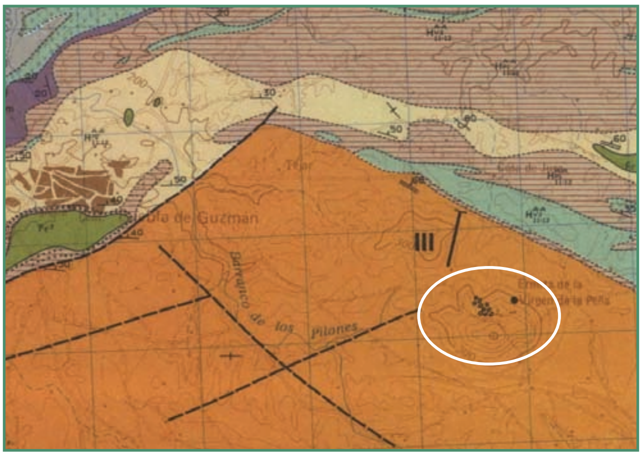
The quarry and techniques: From the photographs we can make out the rugged surface of the outcrop sculpted by weathering. We suppose that the quarrymen detached the surface boulders or millstones.

Product and distribution: The Cerro del Águila production was probably a local alternative to imported millstones such as those in the area brought from Medina Sidonia (i.e. El Berrueco, Cádiz, see CA- 8), about 170 km away (Garrido 2001: 167) .

Dating: Contemporary. The visit related by Garrido (2001) took place in the 1950s. The author adds that the millstones were made by "Uncle Paulino", an old local quarryman, until the arrival of French millstones (Garrido 2001:167).

Rock type: A recent geological study of the hill (Alonso *et al*. 2008) indicates that the surface boulders are principally quartzites. This is not a typical rock for millstones. There may be other very local rock types at this site (Geological map 958, Puebla de Gúzman, 1982).

Detail from the northern rugged face of the Cerro del Águila (photograph from http://montesysenderos.wordpress.com/2012/04/18/minas-de-tharsis-y-ermita-de-la-virgen-de-la-pena/).



Extract of the Geological map 958 (IGME). The orange area is dominated by quartzites, schists and sandstones.

Sources

Hiking itinerary: http://montesysenderos.wordpress.com/2012/04/18/minas-de-tharsis-y-ermita-de-la-virgen-de-la-pena/ [accessed November 16, 2012].

Anonymous black and white photograph: http://www.pueblos-espana.org/andalucia/huelva/puebla+de+guzman/galeria-fotografica/ [accessed January 7, 2013).

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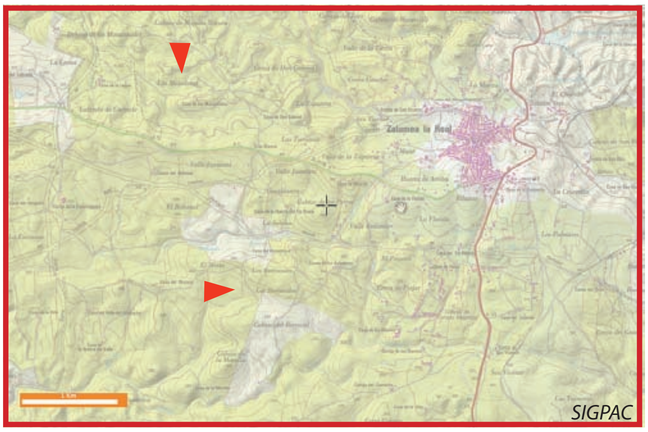
GARRIDO PALACIOS, Manuel. Julio Caro Baroja y los Molinos de Puebla de Guzmán, *Revista de Folklore*, Vol. 21a, no. 45, 2001,164-167. http://www.funjdiaz.net/folklore/07ficha.cfm?id=1945 [accessed November 20, 2012].

HU-6 Zalamea la Real

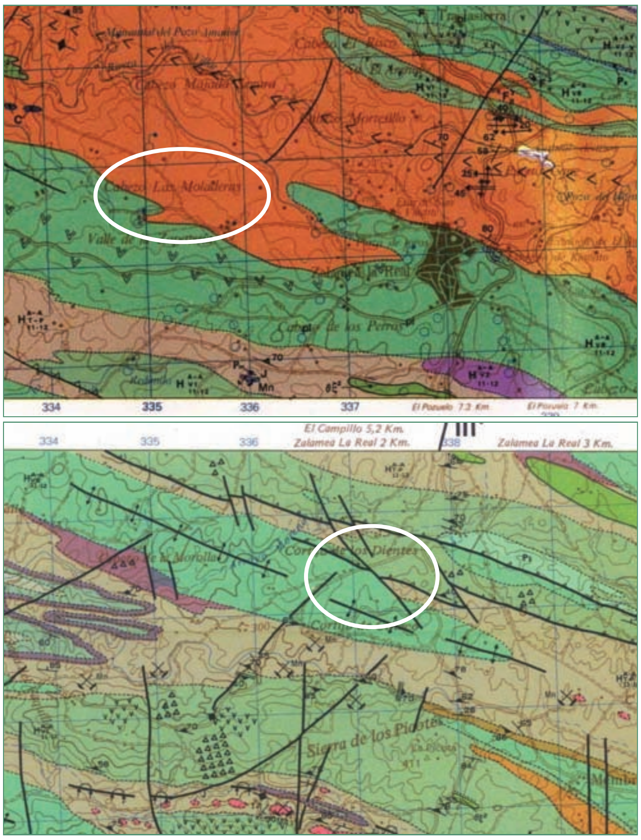


Location and source: Zalamea la Real is a municipality covering a surface of 239 km2. Madoz states that there are several millstone quarries in its surroundings (Madoz 1850, Vol. 16: 450). The author, unfortunately, provides no other relevant information.

Toponymy: The place name *Las Moladeras* 3 km west of Zalamea la Real suggests either millstone or whetstone workings. The rocks in this area, greywakes and slates, however, would point more to the whetstone working. A second potential location is at the *Cabezo del Berrocal* or *Los Berrocales*, 2,5 km southwest of Zalamea. These names are most often synonymous with granite, but in this case, they are for the most part volcanic tuffs or tuffites.

Dating: Middle of the 19th century.

Rock type: Probably granite (from the place names).



Source

Alonso GARCÍA VEIGA. Canteras Medievales de El Campillo, Canteras Medievales de Piedras de Molino. Las Piedras Molares. http://alongarvi.blogspot.com.es/2009/11/canteras-medievales-de-el-campillo.html [accessed November 12, 2012].[accessed November 12, 2012].

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Extracts from the Geological maps 938 and 960 (IGME) The moladeras *place name west of Zalamea la Real associated with unit of greywackes and slates is more likely to correspond with whetstone workings. The* Berruecos *place names to the south, a potential millstone production zone, are, in this case, not related to granite, but to a variety of tuff and tuffites.*

HU-7 Aroche

Fuente de la Aliseda

Latitude: 38º 0’22.06”N
Longitude: 6º 51’54.03”W
Altitude: 456 m

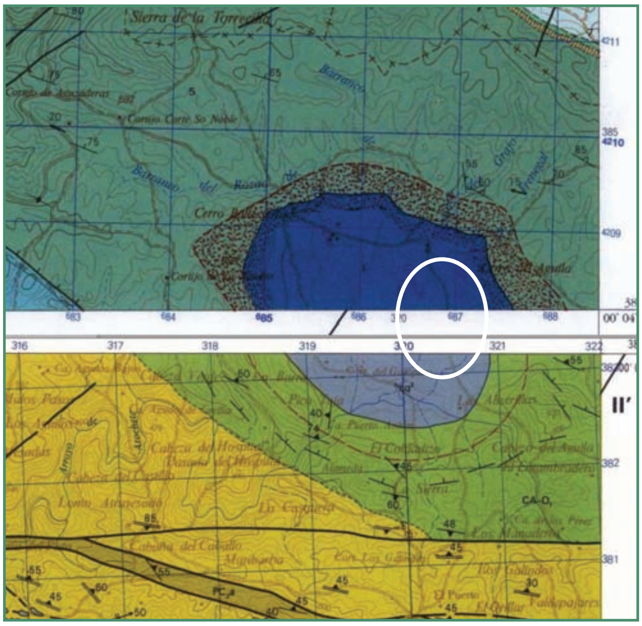
Location: The quarry is near the medicinal waters of *Aliseda*. This well is 10 km northeast of Aroche in a circular basin between the Sierra of Aroche and the Sierra of Castaña.

Sources: Millstone production is cited in a late 18th-century treatise about the medicinal waters of the Aliseda Well (de Dios 1794: 100). The author states that the local folk extracted millstones from the “abundant” outcrops of granite.

Dating: According to Padilla (1999: 278), the granite quarries of the Municipality of Aroche were probably been exploited since Antiquity. Millstone workings are only documented in the late 18th century.

Rock type: Granite (Geological maps 895, Encinasola, 1987/1988; 916 Aroche 1979, IGME).

The 18th-century author de Dios (1794: 100) defines the rock as “*sal y pez*“ granite. The colour white is inferred from *sal* (meaning salt) and black from *pez* (meaning tar, not fish in this case) suggesting a white granite speckled with black dots (probably biotite granite).



Extracts of the Geological maps 895 (top) and 916 (bottom). The quarry exploited a granite unit (blue).

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PADILLA MONJE, Aurelio. Consideraciones en Torno a la Explotación del Mármol en la Bética Durante los Siglos I-II. *Habis*, 30. 1999, p. 271-281.

HU-8 Almonaster la Real

Los Molares

Latitude: 37º 52' 25.73" N
Longitude: 6º 44' 59.78" W
Altitude: c. 585 m

Location and toponymy: *Los Molares* is on the eastern edge of the Sierra de Alcalaboza, 3 km east of Almonaster la Real. The millstone quarry place name has lent itself to the hamlet.

Sources: This quarry is cited twice in written sources. The first, a doctoral thesis on the subject of the Roman period in Huelva, notes the presence of large aborted millstones near the hamlet of *Los Molares* (de la O Vidal 2001: 1170). The second is an item in the archaeological inventory the Province of Huelva (see website).

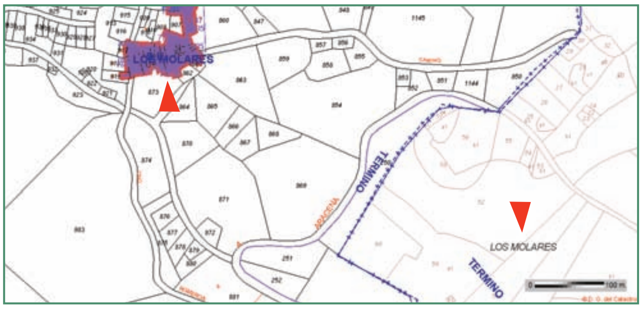
Toponymy: *Los Molares* is the toponym par excellence of millstone quarries. In the cadastre (*SEC*), it corresponds both to the area around the hamlet, as well as to a parcel in the neighbouring Municipality of Santa Ana la Real. It is possible that the quarry was shared by the two municipalities.

The quarry, products and quantification: The archaeological inventory records millstone extraction hollows measuring between 27 cm 1,30 m in diameter, indicating a true extractive quarry. The smaller model (27 cm) is too small to be Roman. Very small Medieval querns are known of this size but cannot be confirmed. The larger model corresponds to watermills. The document provides no data as to the number of extractions.

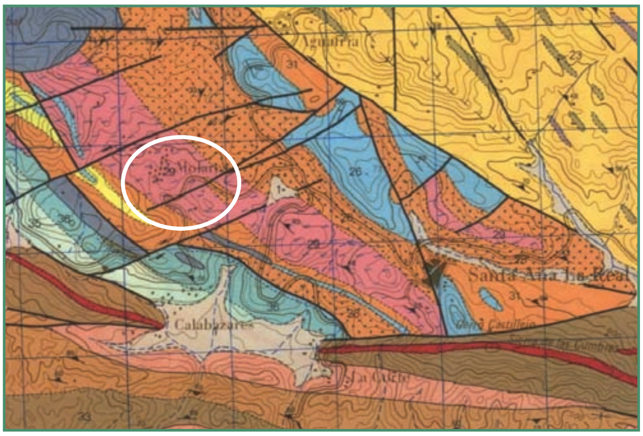
Distribution: There is no data as to the distribution of these millstones.

Dating: The sizes of the larger extractions suggest a Medieval to Contemporary date.

Rock type: Anatectic granite with charnockitic (orthopyroxene-bearing) affinity (Geological map 917, Aracena, 1979).



Extract from the cadastre with the place name Los Molares *in both the Municipality of Almonaster la Real (left) and the Municipality of Santa Ana la Real (right) (SEC).*



Extract from geological map 917 (IGME). The quarry of Los Molares *is in a granite unit (pink).*

Source

Archaeological inventory of the Province of Huelva: Patrimonio Inmueble de Andalucía, Denominación: Molares, Código: 01210040006, Caracterización: Arqueológica, Provincia: Huelva, Municipio: Almonaster la Real; http://www.iaph.es/patrimonio-inmueble-andalucia/resumen.do?id=i14744 [accessed November 20, 2012].

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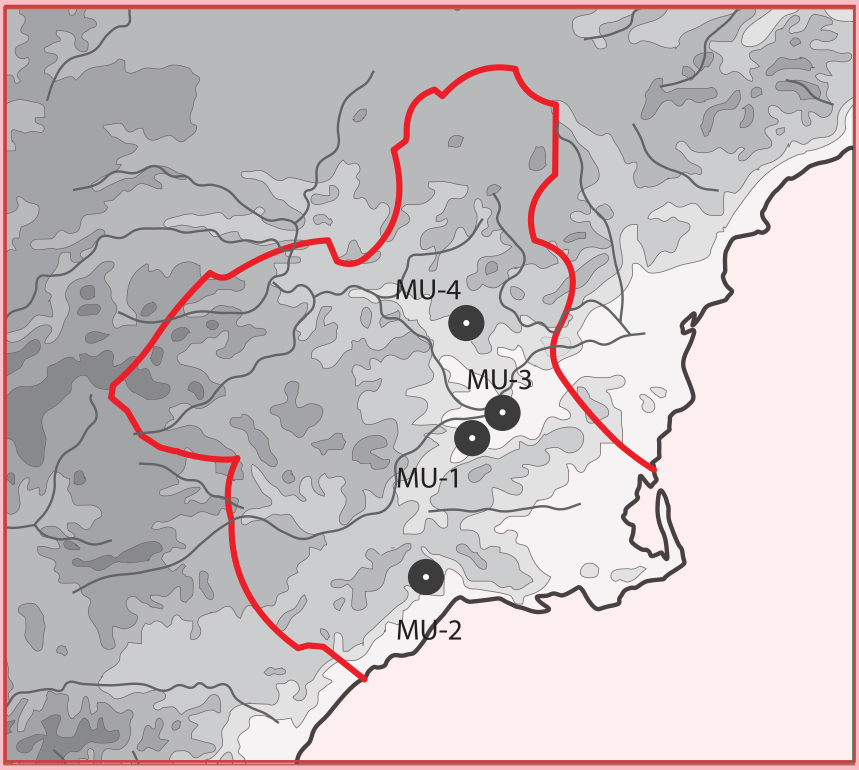
MURCIA

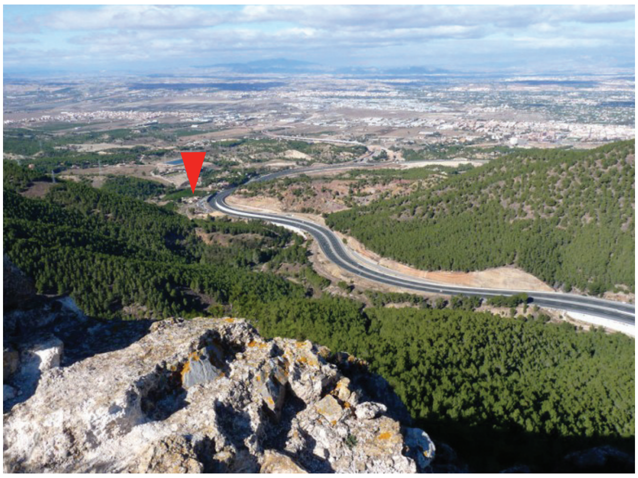
MURCIA (MU)



MU-1 Murcia

Puerto de la Cadena / Casas del Portazgo

Latitude: 37º 54’ 31.58” N
Longitude: 1º 9’ 53.11” W
Altitude: 190 m



View from the Cabezo del Puerto (southeast) of the final stretch of the Cadena Pass. The position of the quarry is indicated by the arrow. The plain of Segura is in the background (from the hiking itinerary: http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/).

Location and generalities: The name of the site comes from a *portazgo* (toll) at the northern entrance of the Puerto de la Cadena near the Castillo de la Asomada, a military construction dating to the 12th century. This mountain pass has been recognised since Antiquity as an important thoroughfare connecting the plain of Segura and the city of Murcia with the Campos of Cartagena and the city of Cartagena on the Mediterranean coast.

Source: The quern and millstone quarry is identified in a hiking itinerary posted on the internet (see source). No old written reference has been identified.

The quarry: The site is a shallow surface quarry evidenced by numerous contiguous horizontal hollows cut into the bed of a ravine at the northern end of the Pass near the recently constructed A-30 motorway.

Techniques: The quarrymen cut trenches (probably with picks) around the future cylinders. Due to extreme weathering, tool marks are not visible.

Products and quantification: A wide variety of millstones were produced. There appear to be three categories of millstones according to their diameters: small rotary handquerns measuring between 40 and 50 cm; medium-sized stones measuring between 70 and 80 cm; and large stones from 1,00 to 1,20 m.

Transport and distribution: The quarry would have benefited from the road through the mountain pass to trade their products either to the plain of Murcia or to the coastal plain of Cartagena. The road, as the name of the site indicates, is known to have had tolls. We ignore, however, if the tolls were contemporary to the millstone production.

Uphill the road has ruts cut directly into the bedrock. These ruts, about 1,20 m apart, might have served to guide carts loaded with millstones. Although rutted roads are documented in quarry context in both Spain (Cisneros *et al*. 1985) and France (Belmont *et al.* 2011: 219-220), we cannot certify that the feature was related to the quarry.

Dating: The date of the exploitation remains uncertain. It is reasonable to assume that the mixture of querns with medium and large millstones places it in the Medieval period, probably during the Islamic domination. The absence of any toponym related to millstone or quarry work also suggests an early date. Madoz’s exclusion of this vast quarry in his description of the natural resources of the Cadena Pass also suggests that it was not being exploited the middle of the 19th century (Madoz 1848, Vol. 11: 729-730).

The presence of a small handmill extractions profiting from the space at the centre of an abandoned large millstone patently reveals that rotary handmills were produced simultaneously or after with larger millstones. This is another argument favouring a Medieval date. The larger extractions, exceeding a metre in diameter could correspond to a Modern or Contemporary phase.

Rock type: Conglomerate with large rounded clasts. This must be a very local facies because the geological map does not indicate conglomerates in the area (Geological map 934, Murcia, 1974).

View of the Cabezo del Puerto. The Medieval Castillo de la Asomada is perched on the top of the mountain in the background.

View from the north of a sector of the millstone quarry in the bed of the ravine.

Millstone hollows along the western edge of the ravine.

Examples of the large hollows (1,70 -1,80 m in diameter) corresponding to millstones approximately 1,00 to 1,20 m in diameter.


Examples of the abandoned millstones measuring 1,10 to 1,20 m in diameter.

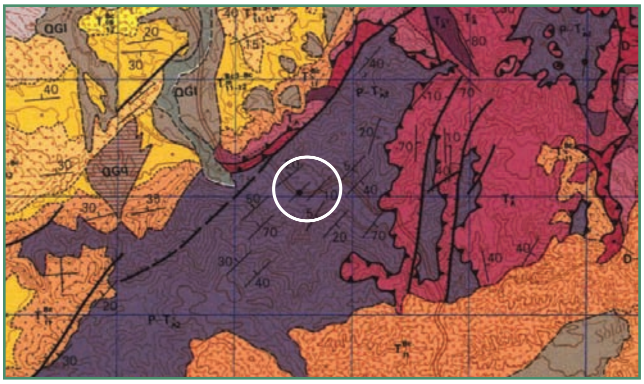

Examples of abandoned millstones measuring between 70 to 80 cm in diameter.


Examples of abandoned rotary querns measuring between 40 to 50 cm in diameter.


Quern and millstone extractions. The example of the quern cut into the heart of an abandoned cylinder (right) indicates that handmills were produced simultaneously or after large millstones (photograph bottom right from the hiking itinerary: http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/).

The tracks of the road cut into the bedrock (from hiking itinerary, senderos de Cartagena).http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/

Detail of the rock showing the form and size of the clasts.



Extract from geological map 936 (IGME). Although the quarry exploited conglomerate, the surroundings of the quarry are dominated by argillite (purple).

Sources

Hiking itinerary: http://senderosdecartagena.wordpress.com/2010/12/16/cabezo-del-puerto-de-la-cadena/ [accessed October 18, 2012].

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MU-2 Mazarrón

Cabezo de la Oliva

Latitude: 37º 36’ 13.03” N
Longitude: 1º 15’ 13.9’” W
Altitude: c. 260 m

Location and generalities: The Cabezo de la Oliva is a mountain about 4 km east of the city of Mazarrón near the town of Las Balsicas. The quarry is reputed to be along the slope called the *Ladera Mala*, a slope that has recently been remodelled by mechanical excavations to build terraces in the framework of a reforestation programme. According to Saturnino Agüera, this site is possibly the source of a series of abandoned querns collected at Los Ceniceros, a Roman villa on a low mound about 3 km to the southeast. The Ceniceros mound is a limestone outcrop and therefore cannot be the source of the volcanic querns.

View from the west of the Cabezo de la Oliva Mountain (extract from Google Maps Street View).

Source: The *Ladera Mala* site, discovered by Saturnino Agüera in the middle 1970s, is listed in the inventory of archaeological sites of Murcia (Agüera *et al.* 1999).

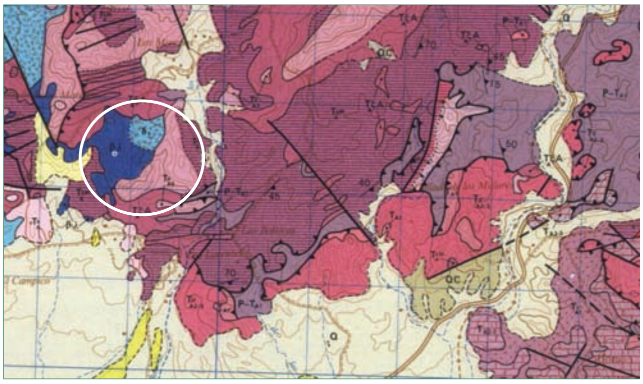
Product: This site is said to have produced both saddle querns and rotary querns. The rotary querns roughouts are analogous to those found at the Roman quern quarries of the Cabo de Gata sites (see AL-1 and AL-2), notably the “sombrero” lower stone type.

Dating: The saddle querns are Pre- or Protohistoric, while the rotary querns are Roman.

Rock type: A petrographic thin-section study of four of the five querns collected at the Ceniceros villa reveal that they are lamproites. This rock corresponds to that of the *Ladera Mala* on the geological map (Anderson *et al.*, in preparation) (Geological map 976, Mazarrón, 1973).

The quern roughouts were discovered at the Roman settlement of Los Ceniceros *(left). The probable source of these querns is the volcanic Cabezo de la Oliva Mountain (centre).*

Unfinished broken rotary querns (lamproites) from the Roman villa of Los Ceniceros stored in the depository of the Museum of Murcia.



Extract from geological map 976 (IGME). The Ladera Mala zone is made up of units of marble and dolomite (pink and purple), as well as igneous (lamproite) outcrops (blue hues).

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Acknowledgements

I thank María MARTÍNEZ ALCALDE, director of the Archaeological Museum of the Mazarrón, and Saturnino AGÜERA for oral information about the site. I also thank Luis de MIQUEL (dir.) and Fátima Gimeno, of the Museum of Murcia for access to the millstones in the depository of Beniahán. The geological analyses are the work of Jane H. SCARROW and Aitor CAMBESES of the University of Granada.

MU-3 Murcia

Cantera de los Porches

Latitude: 37º 56′ 20.93″ N
Longitude: 0º 57′ 54.78″ W
Altitude: 240 - 250 m

Location: Los Porches is in the Sierra de Ataona mountains, about 15 km southwest of the city of Murcia.

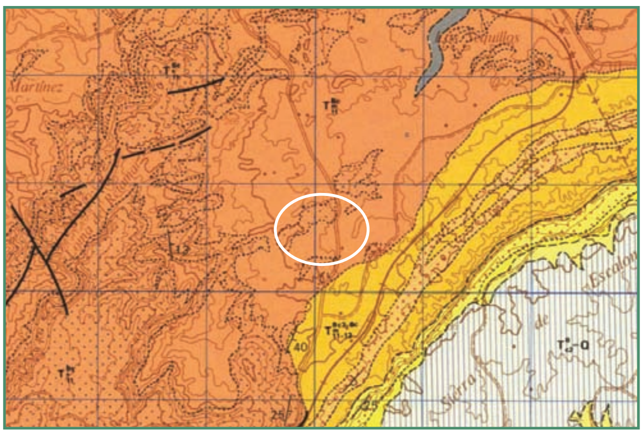
Source: The quarry is identified in a brochure of a hiking trail. From the indications of the brochure, we gather that the site is on the southeastern edge of a mountain.

Toponymy: *Ataona* (or *Altahona*) is a variation of the Arabic word that designates *tahonas*, a term associated both with animal-driven flour mills and bakeries. We ignore if the name is related to a mill or to a quarry.

Product and dating: The only information furnished by the brochure is that millstones are large, suggesting a Medieval to Contemporary date.

Rock type: Sandstones or conglomerates (Geological map 934, Murcia, 1974).

Detail of a pierced, broken millstone (from brochure "Donde vive el Buho" http://www.magrama.gob.es/es/ceneam/programas-de-educacion-ambiental/programas-de-otras-entidades/murcia.aspx).



Extract from geological map 934 (IGME). The orange area corresponds to sandstones, micro-conglomeraterates and loams.

Source

Brochure: Donde Vive el Buho. Finca Municipal los Porches. Programa de custodia del territorio entre el Ayuntamienteo de Murcia y la Asociación Vecinal para el dessarrollo sostenible de Garruchal (ADESGA). http://www.magrama.gob.es/es/ceneam/programas-de-educacion-ambiental/programas-de-otras-entidades/murcia.aspx [accessed November 13, 2012].

MU-4 Fortuna

Sierra de los Baños

Latitude: c. 38º 13’31,42” N
Longitude: c. 1º 7’30.39” W
Altitude: c. 300-350 m

Location: Sierra de los Baños is west of the town of Los Baños. Most of the quarries (for construction material) were on its eastern slope, above an important Roman settlement. Millstone production, however, was on the northern slope along an ancient path leading to the hamlet of Caprés.

View of the eastern slope of Sierra de los Baños (extract from Google Map Street View).

Source: The site is identified in a brief study of oil roller production (Matilla Seiquer 2001), one of the first articles addressing specifically the question of millstone production in southern Spain.

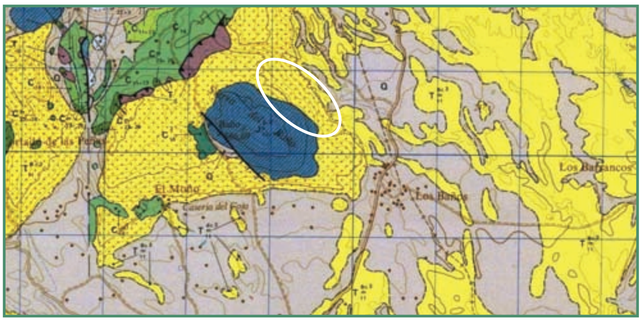
The quarry: The research by Matilla singles out an abandoned Roman ring-type upper stone (*catillus*) (Matilla Seiquer 2001: 273, photograph 7; 274) among a group of unfinished oil rollers scored from surface blocks (Matilla Seiquer 2001: 272).

Ring-type upper stone (from Matilla Seiquer 2001: 273, foto 7).

Products: The unfinished upper stone is, according to the author, 80% complete (Matilla Seiquer 2001: 273, photograph 7; 274). Its dimensions (60 cm in diameter; 43 cm in interior diameter and 45 cm thick) and its “*rosco*” (i.e. “doughnut”) shape are characteristic of Roman ring-mills, a type mill common in the south of Spain and northern Morocco (notably at *Volubilis*) in Roman times.

Dating: We have observed similar ring-mill fragments in the depository of the Archaeological Museum of Murcia (nos. 30-31, Anderson *et al*. 2011: 16). One is volcanic (lamproite), while the other, also about 60 cm in diameter, is a conglomerate.

Rock type: Matilla Seiquer does not specify the rock of the ring-mill. Due to the absence of volcanic outcrops in the area, there is little chance that it is of volcanic material. It is more likely either a conglomerate, sandstone or limestone, the local outcrops (Geological map 892, Fortuna, 1973).



Extract from geological map 892 (IGME). Limestone in blue. Conglomerate and sandstone in dotted yellow.

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CASTILLA LA MANCHA
CIUDAD REAL (CR)

CR-1 Almodóvar del Campo

Sisapo / Castillejo de la Bienvenida

Laitude: 38º 39' 1.80"N
Longitude: 4º 31' 17.91"W
Altitude: 710-720 m

View from the southeast of the excavations of the Roman city of Sisapo. *In the background are the volcanic domes where construction blocks and millstones were exploited.*

Location: The quarry of *Sisapo*-Castilejo de la Bienvenida is 500 m from the Roman city of *Sisapo* in the heart of the vast plain between the mountain ranges of the Sierra de la Solana and the Sierra de la Umbría. The quarry occupies three small volcanic domes, that represent the southwestern-most outcrops of the vast (approximately 5000 km2) Campo de Calatrava volcanic district.

Source: Although the site has been known as a quarry for some time (Fernández *et al*. 2002: 151), quern and millstone production was only identified during a field survey in company of Tor Grenne of the NGU and presented in the colloquium of Rome (Anderson *et al*. 2011).

The quarry and techniques: The millstone working site is a true extractive quarry where cylinders were cut directly into the rock, probably with picks, resulting in multiple circular hollows. This technique differs from the detaching angular blocks from columnar jointing, the technique identified at most other volcanic rock exploitations (see AL-1 and Harms & Mangartz 2002). Extractions are either grouped or isolated.

On the rare visible sectors of the quarry floor there are examples of single, large trapezoidal holes at the base of the cylinder point. These cavities were meant to lodge wedges, possibly of wood, to split the millstone from bedrock.

Adjacent to the millstone workings is a block quarry (ashlars) with a rectangular baulk in its centre. A similar feature are known at the Frailes millstone quarry of Cabra (CO-1). A much more spectacular version is the pinnacle in the Roman block quarry of El Mèdol in Tarragona. There nature of these features is still a question of debate (quarry fixture from which to measure the quantity of stone extracted, a landmark representing the technical capacity (Gutiérrez 2009: 156-157). It could also simply mark a limit between different concessions.

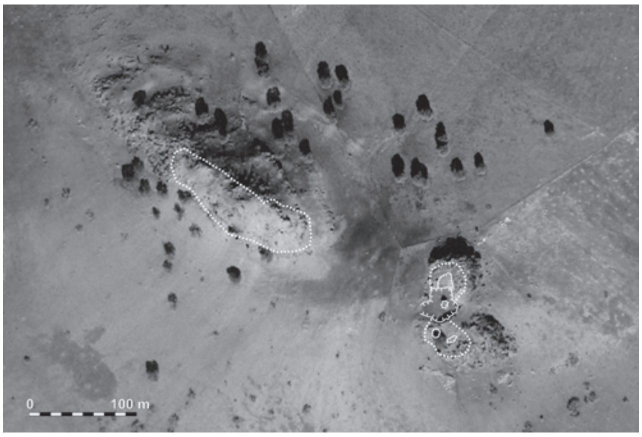
In some sectors, large parts of the bedrock are missing and now backfilled with earth. It is, however, not possible to determine if querns, millstones or ashlars were hewn from these areas.

Products and quantification: The querns extracted measure 40 cm in diameter, while the diameter of the larger extractions, most likely ring-mills, range from 70 to 90 cm. It is possible that hundreds of millstones were extracted.

Transport and distribution: The site obviously served the needs of the city of *Sisapo*. It certainly exported its products far beyond the city profiting from vast trade network known in Roman times.

Dating: The chronology of the site cannot be established with precision. The sizes of the extractions, the proximity of the Roman city and the propensity of the Romans for volcanic millstones, point to Roman times. The relative thickness of the larger extractions (in proportion to their diameter) suggests ring-shaped upper stones, a type of Roman mechanism well represented in the south of Spain.

Rock type: The rock is a hard, dark grey, vesicular olivine melilitite (Anderson *et al*. 2011). Basalts according to the geological maps 834, San Benito, 1983 and 835, Brazatortas, 1989).



Detail of the three volcanic domes (SIGPAC).

View from the southeast of the largest dome (C).

View from the south (from Dome A) of the quarry. In the forefront is the block quarry (a) with the central baulk (b). On the slope of Dome B is the quern and millstone quarry (c).

View from the northeast of the sector of Dome B with multiple, contiguous quern extractions.

Extraction hollow of a rotary quern measuring 40 cm in diameter.

Abandoned cylinder of a rotary quern measuring about 40 cm in diameter.

Defective extraction.

Extraction hollow of a millstone measuring 80 cm in diameter.

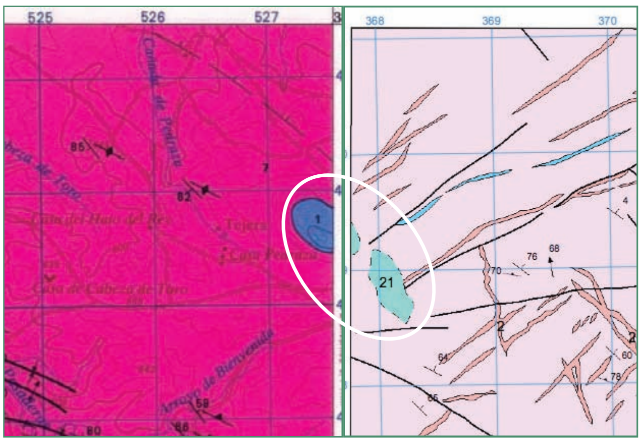
Extraction hollow of millstone measuring about 80 cm in diameter.

Example of an abandoned millstone extraction (probably the lower stone of a ring-mill) on Dome C.

Abandoned millstone measuring about 80 cm in diameter. The cavity visible on the upper face is indicative that it was destined to be a ring-type upper stone (from Fernández et al. *2002: 121, fig. 6: 4).*

View from the north of the quarry between Domes A and B. This large area with a central baulk was probably exploited for construction blocs.

Abandoned quern roughouts measuring about 40 cm in diameter (from Fernández et al. *2002: 121, fig. 6: 5).*



Extract from geological maps 834 and 835 (IGME). The quarry coincides with basaltic outcrops (blue on left map and turquoise on right map) in the heart of a unit of slate and greywacke (pink).

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CR-2 Bolaños de Calatrava

Cantera de las Herrerías

Latitude: 38º 53′ 22.41″N
Longitude: 3º 38′ 55.51″W
Altitude: 660 m

Orthophoto of the quarry of Las Herrerías (SIGPAC).

View from the northeast entrance of the modern industrial quarry of Las Herrerías (extract from Google Maps Street View).

Location: *Las Herrerías* is about 1,5 km southwest of Bolaños de Calatrava. It is currently a vast rock exploitation for construction material. In the eastern sector of the quarry, the present workmen have conserved 10 unfinished or aborted Roman millstones brought to light during their work.

Source: The millstones were identified during a geological survey by the geologist Aitor Cambeses of the University of Granada.

Toponymy: The name *Herrerías*, meaning the workshop where iron is either smelted or fashioned into objects (smithy), is at times associated with stone work because of the stone worker's need of a smithy for the maintenance of the iron tools. This place name could therefore be indicative of a former smithy at the site.

The quarry: We have no information about the original Roman millstone exploitation, its size, and extraction techniques. Its features have probably been destroyed during the more modern work.

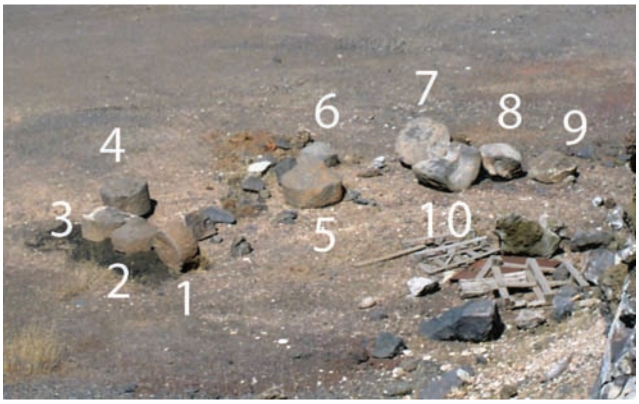
Products and quantification: Most appear to be man- or animal-driven millstones. It is possible that the smallest, no. 6, is a rotary quern. There is no indication that any of these roughouts, by means of the total piercing of the lower stone, was in the process of being fashioned into a watermill.

The scale of production cannot be determined. We can imagine that the present workmen on conserved the more recognizable and better-conserved stones. A large number of smaller fragments have probably been recycled for construction material. In any case the outcrop had the potential for a vast production.

Transport and distribution: This quarry exported its products long distances through the long established trade network.

Dating: Roman, based on typological criteria.

Rock type: Dark, vesicular volcanic rock. Nephelinite olivine lava or olivine melilitite lava (Geological map 785, Almagro, 1985).



View of the 10 Roman millstones salvaged by the workers of the present-day rock quarry.

Detail of an unfinished ring-shaped upper stone (10).

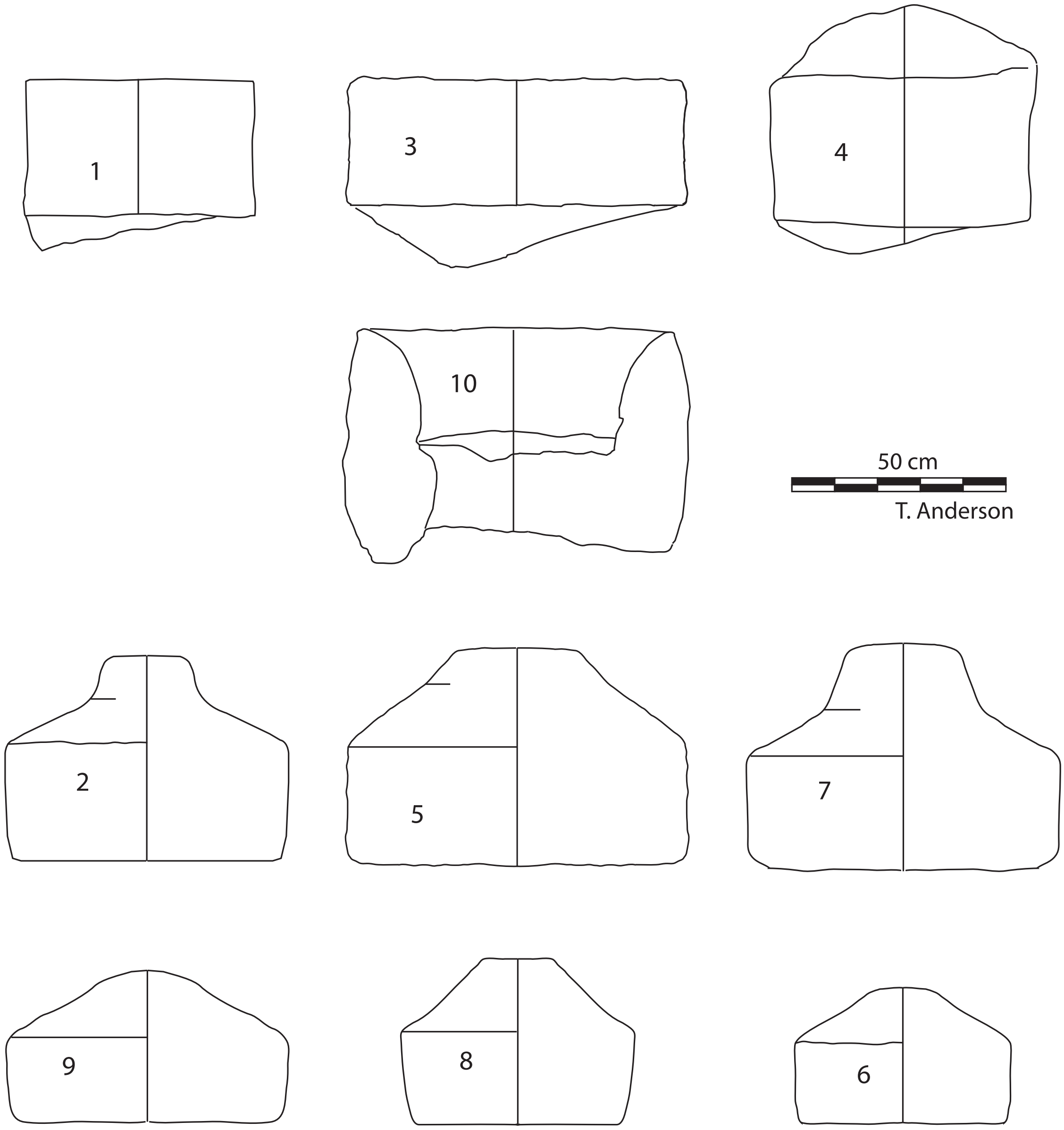
Left to right: 2, 3, 4 and 5 (foreground).

Left to right: 9,8,10

Left: 5 right (background); right 7 (upside down).

Abandoned millstone roughouts (1-3 from right to left).

Foreground: 6; background: 5.



*Rough sketches of the sections of the querns and millstones. Nos. 1, 3, 4 and 10 are upper stones (*catilli*); 2, 5, 7, 9, 8, and 6 are lower stones (*metae*). All, except possibly no. 6, correspond to small man- or animal-driven mills. Number 10 is a ring-mill upper stone (*catillus*) fragment (drawings by T. Anderson).*

Extract from geological map 785 (IGME). The quarry is located in the unit of nephelinite olivine lava (green). There are equally olivine melilitite lavas (pink) in the sector.

Acknowledgements

My warm thanks go to Aitor CAMBESES, Department of Geology, University of Granada, for alerting me of presence of these millstones.

CR-3 Chillón district

Generalities: The Municipality of Chillón covers a surface of over 200 km2 in the southwest of the Province of Ciudad Real along the border of the Autonomy of Extremadura. This is a region with a long history of mining, notably the cinnabar mines of Almadén.

Source: Madoz records a granite millstone quarry (Madoz 1847, Vol. 7: 326-327). The author does not provide any other information concerning the site or its location.

Dating: Middle of the 19th century.

Location and rock type: According to the geological maps, there is no granite in the current Municipality of Chillón. If Madoz is right in his definition of the rock, the nearest source is about 12 km to the west of Chillón, at the eastern extremity of the Garlito granite-diorite outcrop. This outcrop, although near the Chillón border, is in the neighbouring autonomy of Extremadura and is now partially under the waters of the Serena dam (Geological maps 807, Chillón; 808, Almadén; 781, Siruela; and 782, Valdemanco del Esteras, IGME).

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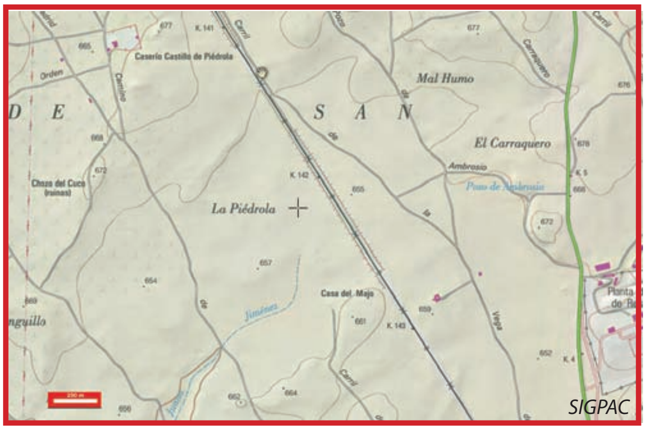
CR-4 Alcázar de San Juan

Pedrizas de Piédrola

Latitude: c. 39º 26′ 24.54″ N
Longitude: c. 3º 15′ 1.94 W
Altitude: c. 650 m



Location and generalities: *Pedrizas de Piédrola* is a place name in the flatland a few kilometres north-west of Alcázar de San Juan, in the heart of the Mancha, a region made famous by the tale of Don Quixote. White windmills, like the "giants" the errant knight grappled, dot the landscape, notably at the Cerro San Antón south of Alcázar.

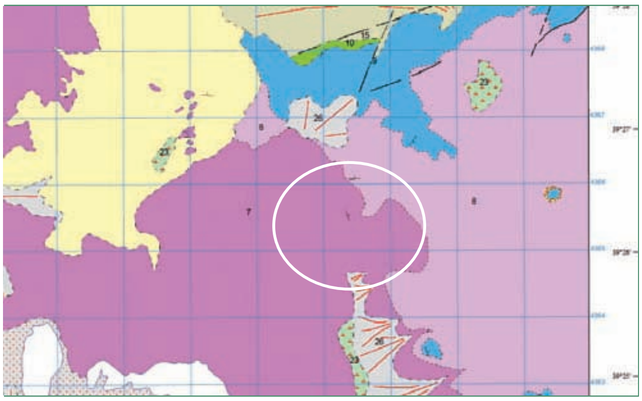
Source and distribution: In a report by the municipality about the potential of "valorising" the windmills of Cerro San Antón (Sánchez Ruíz 2009), Piédrola is cited as the most productive of all millstone quarries in the Mancha region. This suggest its production travelled beyond the local area dominated by windmills.

Toponymy: *Pedrizas* means a surface covered naturally by rock and the name *Piédrola* also certainly derives from "rock". Both names are evocative of rock work.

The quarry: Now under "Special Protection" of the Municipality, the site presents abandoned millstones in different stages of production. According to José Sánchez Ruíz, the millstones are large and probably intended for the numerous windmills in the area.

Dating: Late Medieval to Contemporary times.

Rock type: Sandstones or dolomites (Geological map 713, Alcazar de San Juan, 1991). The exact nature of the rock is not confirmed.



Extract from the geological map 713 (IGME). The quarry is a unit of sandstone and dolomite (purple).

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Acknowledgments

I thank José SANCHEZ RUÍZ of the Municipality of Alcázar de San Juan for confirmation of the site's location.

CR-5 Granátula de Calatrava

Las Canteras

Latitude: 38º 46′ 1,22″ N
Longitude: 3º 43′ 30,33″ W
Altitude: 640 m

Location: The site is 2,5 km southeast of Granátula de Calatrava at the place name *Las Canteras* (the quarries), opposite the archaeological site of Oreto y Zuqueca. During our visit, the site was under the waters of the Jabalón River dam.

Sources: The quarry was filmed in a television documentary available on the internet (Labordeta, *Un país con la mochila*; see sources). It also is cited briefly in a website about the windmills of the area (see J. J. Donoso, Molinos de viento website).

The quarry and products: From what we can gather from the film and several photographs posted on Google Maps, the quarry appears to be a shallow surface exploitation with large cylindrical hollows carved into bedrock. The site is also mentioned in the blog of Juan Jesús Donoso (see sources).

Transport and distribution: This site is on the banks of the Jabalón River and could have benefited from fluvial transport. A railway station, now abandoned, is also adjacent to the site. We do not know, however, if the quarry was exploited when the railway was active.

Toponymy: *Las Canteras* (the quarries) is a common place name for millstone quarries.

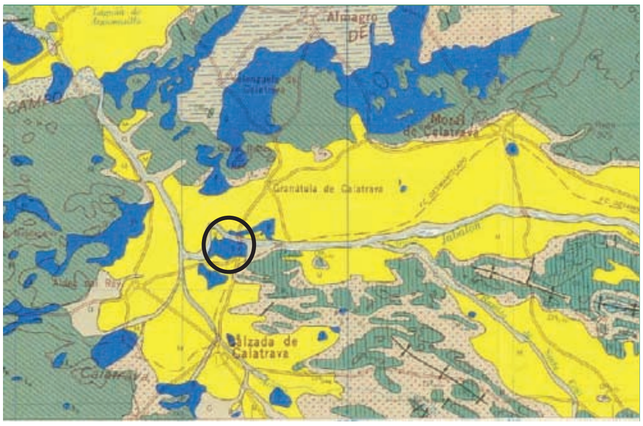
Dating: The large extractions, at least 1 m in diameter, indicate an exploitation dating from Medieval to Contemporary times.

Rock type: Limestone (Geological map 61,1:200000, Ciudad Real, 1970, IGME). From the photograph, the limestone appears to be extremely porous. This is an excellent example of a non-volcanic rock exploited in the heart of the Campos de Calatrava Volcanic District (Anderson *et al*. 2011: 163).

View of a sector of the millstone quarry. Waters of the Jabalón Dam are seen in the background (from Google Maps, Jumadogo).

Detail of an extraction hollow (from Google Maps , Jumadogo).

Detail of an unfinished millstone attached to the bedrock (photograph from the website Molino de Viento, Juan Jesús Donoso: http://granatula.com/del-pueblo/granatula-y-sus-molinos/molino-de-viento).



Extract from geological map 61, Ciudad Real, 1970 (IGME). The quarry is in the unit defined as limestone (yellow). The adjacent blue units are volcanic basalt.

Source

Juan Jesús DONOSO websiteMolino de Viento: http://granatula.com/del-pueblo/granatula-y-sus-molinos/molino-de-viento [accessed November 12, 2012].

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Acknowledgements

I thank Juan Manuel DONOSO GÓMEZ, archaeologist from Granatula de Calatrava, for oral information about the quarry. I also thank Juan Jesús DONOSO AZAÑON for his photographs of the site.

CR-6 Granátula de Calatrava

Cerro Columba

Latitude: 38º 46′ 0.68″ N
Longitude: 3º 46′ 5.34″ W
Altitude: c. 780 m

Examples of broken volcanic roughouts at the archaeological site of Oreto y Zuqueca.

View towards the northwest from the top of the Cerro Columba. The presumed quarry is near the modern bridge seen in the background crossing the Jabalón River Dam.

Location, dating and generalities: This Cerro Columba is a large and low volcanic dome along the Jabalón River, three km west of the Roman and Medieval settlement of Oreto y Zuqueca. It is also near the presumed location of the Roman city of *Oretum* at the Cerro Domínguez. The Jabalón River at this point presents a wide bend provoked by the lava flow from the dome. The existence of a quarry is based on a four aborted quern roughouts typical of the Roman period among a dozen of highly porous, dark volcanic millstones at Oreto y Zuqueca (Aguirre 1948: 121). Generally, a group of unfinished, broken millstone indicates the existence of a nearby quarry. The site was identified in a field survey in the company of Tor Grenne of the Norwegian Geological Survey (NGU).

Sources: Information about this site was provided by the archaeologists Juan Manuel Donoso Gómez and Helena Romero Salas. The site was presented in the millstone colloquium of Rome (Anderson *et al.* 2011: 159-161).

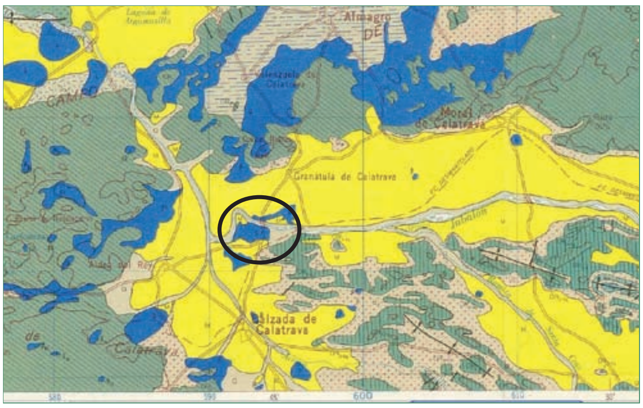
The quarry: It is generally accepted that a scarp was created where a northward lava flow from the Cerro Columba intersected with and displaced the Jabalón River. At this location the rock presents columnar jointing, a feature known to have been exploited for millstones at other Roman quarries, for example, in the Eifel in Germany (Harms & Mangartz 2002). This was reputedly exploited for construction material for the city of *Oretum* (2 km to the east), as well as for a Roman bridge (Alañon Flox 1982: 230) adjacent to the quarry of a major N-S Roman road. This feature is now also under water.

It cannot be excluded that the unfinished querns of Oreto y Zuqueca come from the millstone quarry identified at Las Herrerías (see CR-2). The rock of both exploitations are olive basalt. We suppose, however, in this case, that millstone makers would have given preference to a local rock (4 km) over one coming from 17 km away.

Transport and distribution: The site obviously produced for the city of *Oretum*. It also certainly exported by both land and water its products far beyond its region. Volcanic rocks are known all over Roman *Hispania*.

Products: Querns and possibly millstones.

Prominent columnar jointing at the Cerro Columba (from the website of the Geomorfología, Territorio y Paisaje en Regiones Volcánicas research group: http://www.uclm.es/profesorado/egcardenas/columba.htm).



Extract from geological map 61, Ciudad Real, 1970 (IGME). The Cerro Columba is in the blue volcanic basalt unit.

Transport and distribution: This potential production centre would have benefited from the Jabalón River to transport its products.

Rock type: Olivine basalt (Geological map 61,1:200000, Ciudad Real, 1970, IGME), Anderson *et al*. 2011: 159-161).

Source

Website of the research group "Geomorfología, Territorio y Paisaje en Regiones Volcánicas", University of Castilla La Mancha, Columba, El Cabezuelo, las Cuevas: http://www.uclm.es/profesorado/egcardenas/columba.htm [accessed May 23, 2012].

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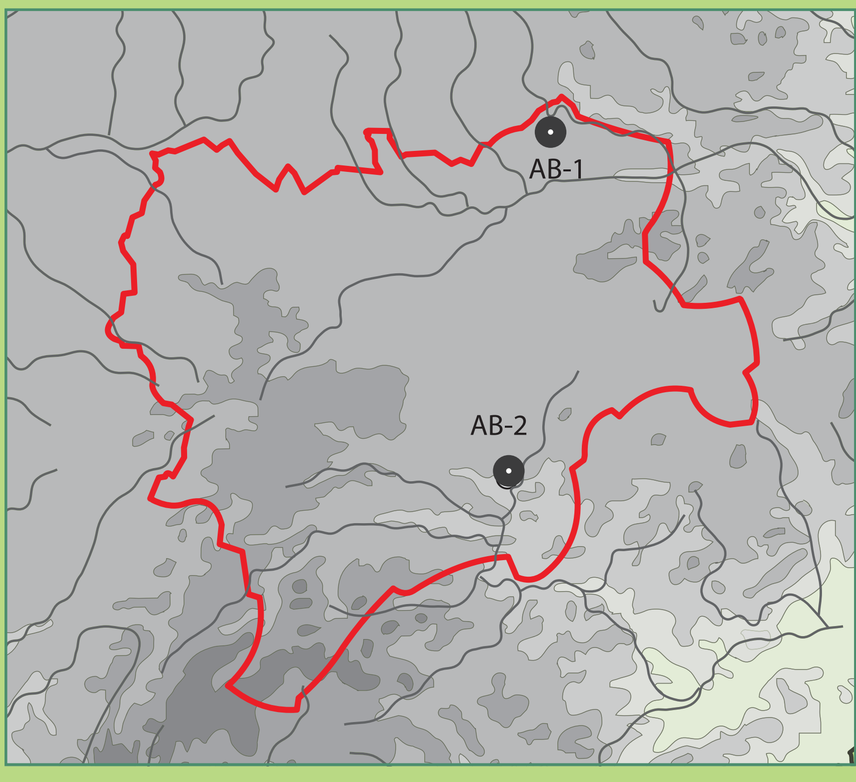
Acknowledgements

I thank the archaeologists J Helena ROMERO SALAS and Juan Manuel DONOSO GÓMEZ, archaeologist from Granatula de Calatrava, for oral information about this site.

CASTILLA LA MANCHA

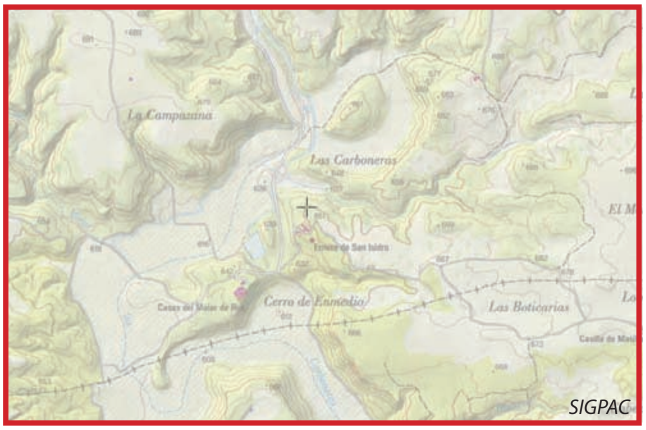
ALBACETE (AB)



AB-1 Fuentealbilla

El Molar

Latitude: 39º 14’ 9.98”N
Longitude: 1º 32’ 48.41”W
Altitude: c. 640 m



Location and generalities: The millstone quarry of *El Molar* is in the Municipality of Fuentealbilla in the northeast of the Albacete Province about halfway between Fuentealbilla and Abengibre. It is on the northeastern slope of a hill near the Ermita de San Isidro. It is interesting to note that the coat of arms of the town of Abengibre includes a silver millstone in its upper field, possibly an allusion to the local tradition of millstone production.

Sources: The earliest indirect reference to millstone production comes from the *Survey of the Marques de Ensenada* (1750-1754) which lists a *picapedrero de molinos* (millstone quarryman) among the residents of the town. Madoz, a century later, cites the millstone workings twice, in descriptions of both the town of Abengibre (Madoz 1845, Vol. 1: 51) and Fuentealbilla (Madoz 1845, Vol. 1: 256).

What is interesting about Madoz’ reference is that the Fuentealbilla rock is described as having a grain that is not compact and not as “appreciated” as that of the sandstone from Barcelona. This is a reference to the celebrated millstone quarry of Montjuïc that traded its products along the northeastern coastline of Spain, the Balearic Islands, and even to France and Italy (Campany 1779; Barbera 2003: 194; Español 2009: 966-967).

The quarry: F. Castillo, of Fuentealbilla, notes that abandoned and broken millstones are still present at the site and that there are circular hollows in the bedrock, indicating it to be a true extractive quarry.

Toponymy: The term “*molar*”, deriving from the Latin “*mola*” (millstone), is a place name at times associated with millstone production.

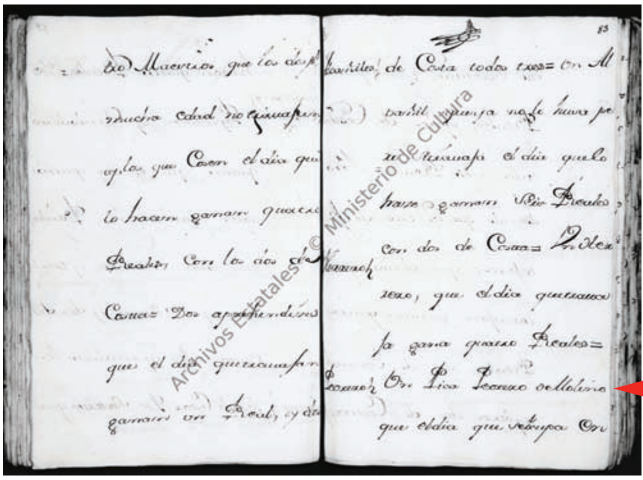
Products and quantification: We only have evidence of the production of large millstones for watermills (and possibly windmills). We ignore the number produced at the site.

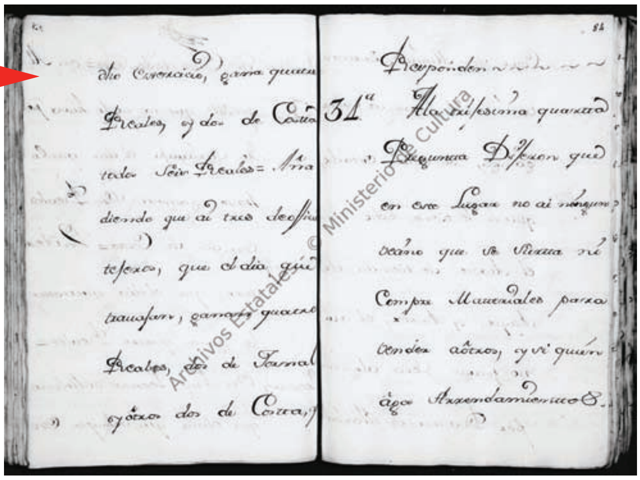
Distribution: Due to the different references, it is conceivable that the quarry traded its millstones beyond the local area.

Dating: The reference in the *Survey of the Marques de Ensenada* (1750-1754) establishes production in the middle of the 18th century, whereas the Madoz references confirms it also a century later.

Rock type: Limestone (Geological map 743, Madrigueras, 1977).

Coat of arms of the town of Abengibre with a silver millstone (from http://es.wikipedia.org/wiki/Abengibre).



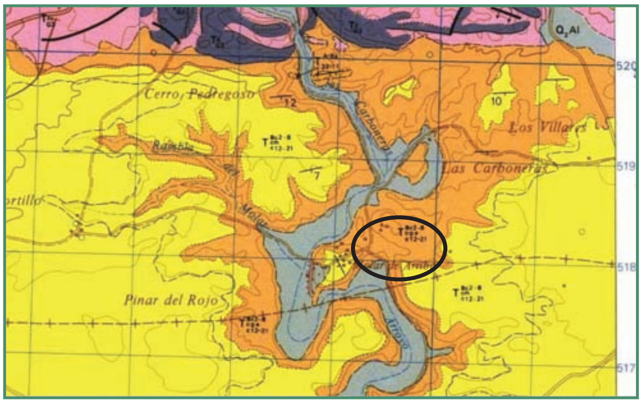


Extract of the Survey of the Marqués de la Ensenada (1750-1754) of the town of "Avengibre" (modern Abengibre). Among the professions of the town is that of "Picapedrero de molino" (millstone maker) *(from Catastro de Ensenada, http://pares.mcu.es/Catastro/servlets/ServletController).*

Transcription of the extract about the millstone maker from the Survey of the Marqués de Ensenada:

"Pedrero: Un Pica Pedrero de Molino que el dia que se ocupa en dicho exercicio, gana quatro Reales, y dos de Costta todos Seis Reales".

Section 32 (pages 83-84).



Extract from geological map 743 (IGME). Limestone (orange).

Sources

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Acknowledgments

I would like to thank Francisco CASTILLO of the Municipality of Fuentealbilla for his oral description of the site.

AB-2 Hellín

Pitón de Cantarix

Latitude: 38º 25' 1.08" N
Longitude: 1º 35' 37.58 W
Altitude: c. 590 m

Location: The Pitón de Cantarix is a volcanic dome in the centre of the Sierra de las Cabras, about 12 km southeast of Hellín and near the border of the Autonomy of Murcia.

Sources and products: The authors of an archaeological article on the Roman occupation of the Minatda-Agramón Valley record that volcanic querns from the settlements of La Horca and El Tolmo come from the Sierra de las Cabras (Jordan *et al.* 1984: 222-223, 227). The settlements are respectively 5 and 3 km from this outcrop. It is perfectly reasonable to assume this site to be a quern quarry because to the presence of large columnar jointing.

Cobblestone workings from recent times are reported along the prominent columnar jointing of the dome's southeastern flank (from http://jumillanatural.blogspot.com.es/2013/01/volcan-de-cancarix.html). This sector, from the photographs, resembles the quern quarry of Mayen, in the Eifel of Germany (Harms & Mangartz 2002). The geological map handbook also cites old extractive work, possibly a reference to the cobblestone workings (IGME 868: 41). There is, however, no recorded evidence at the site (such as abandoned roughouts) to confirm quern production.

Dating: Finds of volcanic querns in nearby Roman settlements dates the quarry to Roman times. According to Jordan (1997: 17), millstones of this material were used in the 20th century in *cortijos* in the area. We suppose they ground animal fodder.

Rock type: Jumillite volcanic rock (Geological map, 868, Isso, 1980). In more recent studies, the geological unit is classified as a dark lamproite with hexagonal columnar jointing (see Guía Geológica). In any case, the site is one of the northern-most volcanic outcrops of the SE Spanish Volcanic District and one of the rare sources outside the Provinces of Murcia and Almería.

View of the columnar jointing along the southeastern flank of the Pitón de Cantarix (from http://jumillanatural.blogspot.com.es/2013/01/volcan-de-cancarix.html).

Talus formed at the base of the columnar jointing (from http://jumillanatural.blogspot.com.es/2013/01/volcan-de-cancarix.html).

Extract from geological map 868 (IGME). The dark unit is "Jumillita" volcanic rock and is the presumed location of the quarry. More recent geological research defines the rock as a lamproite.

Sources

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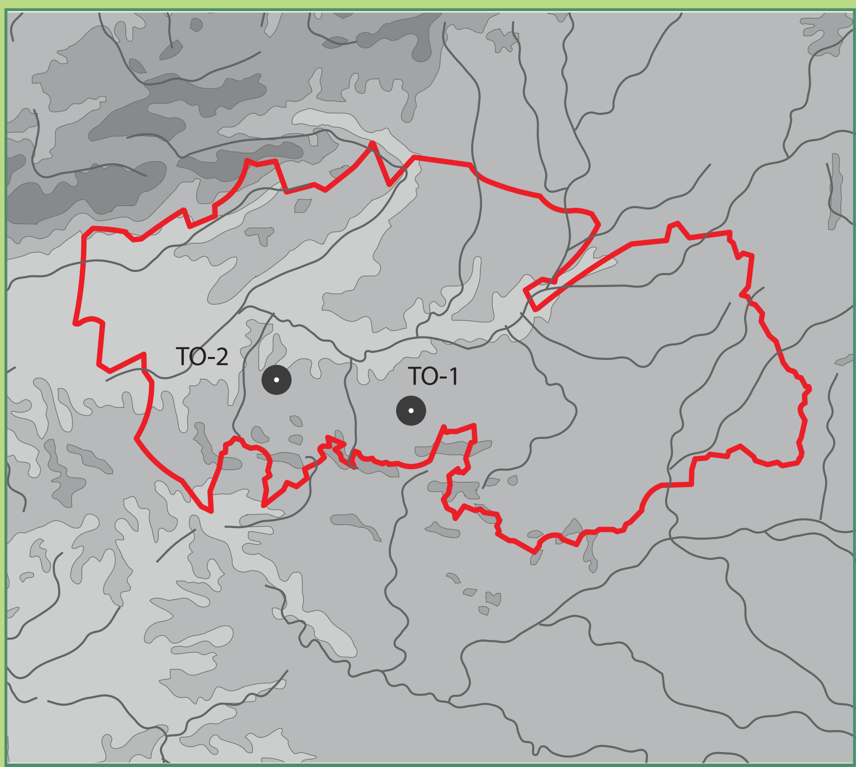
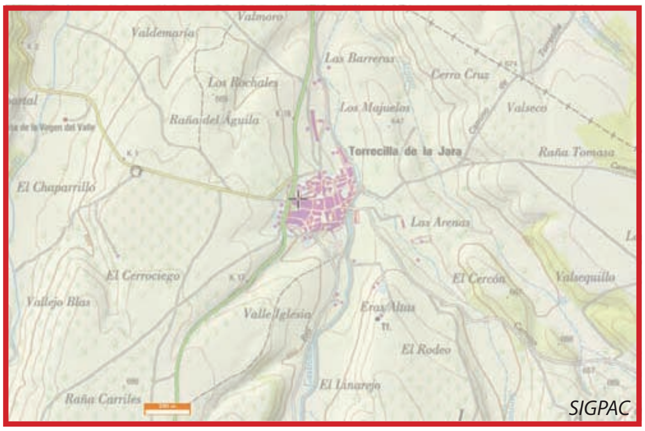
CASTILLA LA MANCHA
TOLEDO (TO)



TO-1 Torrecilla de la Jara



Location: Torrecilla de la Jara is a small town in southwestern Toledo in the flat Valle de los Castaños.

Source: The sole reference to millstone production is the response dating to the 9th of May, 1782, by Lucas Fernandez de la Sierra, the village priest, to a questionnaire from the Archbishop Lorenzana of Toledo concerning the natural resources of the town. His answer to question 14: "[the town] only has a few boulders from which millstones were hewn for flour mills".

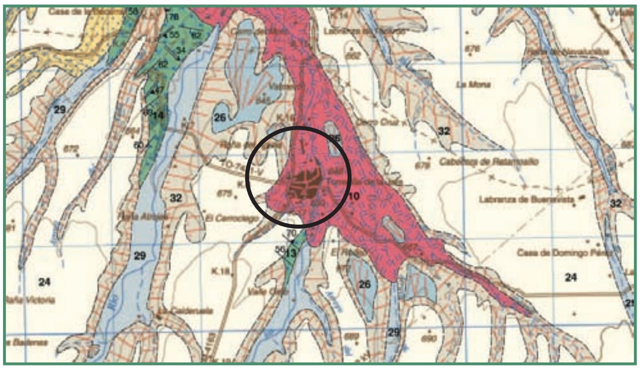
The quarry: The use of the term "*cantos*" is an allusion surface boulders that abound in the area.

Distribution: From the written sources the site produced for the local mills.

Dating: End of the 18th century.

View from the west of the town of Torrecilla de la Jara (extract from Google Maps Street View).

Rock type: The main lithic material in the surroundings of Torrecilla is granite. We cannot exclude, however, that blocks of quartzite or breccia, in the plains beyond the town, were exploited for millstones (Geological map 655, Navalmorales, 1990).



Extract of the geological map 655 (IGME). The granite unit is in pink. The other units in the surroundings (cream,beige, blue) correspond to deposits with surface blocks of quartzite and breccia.

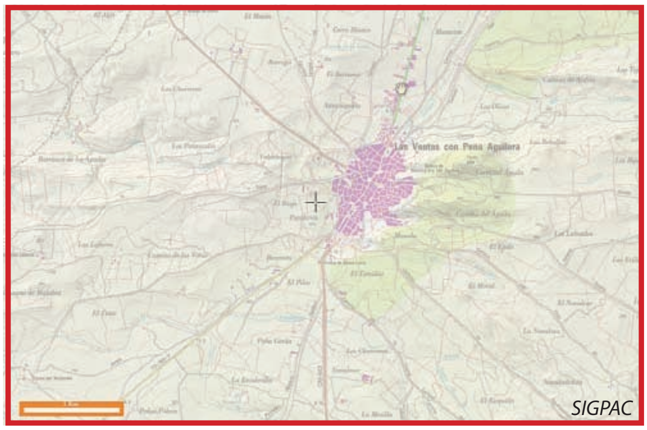
The response to the questionnaire of 1782 of the Archbishop Lorenzana of Toledo

"A la14.ª [sic] pregunta debo decir no tener este pueblo aguas minerales ..., si solo tiene algunos cantos que sirven para sacar piedras para los molinos de pan ..."

Sources

The responses to the questionnaire of Archbiship Lorenza of Toledo (1782) for the town of Torrecillas de la Jara were consulted at: http://www.torrecilladelajara.com/historia.htm [accessed 15 of October 2012].

TO-2 Las Ventas con Peña Aguilera



View of the Cerro del Águila, one km to the east of the centre of Las Ventas con Peña Aguilera. This photograph illustrates the numerous surface boulders of granite that are typical of the region (photograph by Cogolludo, Google Maps).

Location of the place name Berrueco *on the northern outskirts of Las Ventas con Peña Aguilera, a name synonymous with granite, at times associated with millstone quarries (SEC).*

Location of the place name Berrueco *on the northern outskirts of Las Ventas con Peña Aguilera (Google Maps Street View).*

Location: This municipality is in the south of the Province of Toledo and covers a surface of 104 km2. It includes both the wide plain as well as the Saltadero and a large section of the Peñafiel, mountains that are part of the Montes de Toledo range. The exact location of the quarry is not known.

Sources: The response to question 28 of the *Survey of Philip II* (1576) records that Ventas con Peña Aguilera quarries furnished not only stones for the Cathedral and the Alcázar (fortress) of Toledo but produces "the best granite millstones in all of Spain" (Viñas & Paz 1951: 216).

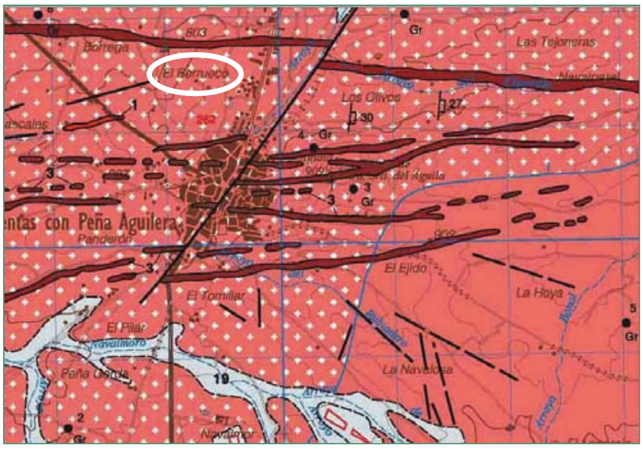
A second reference to millstone production dates to a protocol in 1587 (leg. 313/2 a), recording that the millstones for a restored watermill in Colmenar de Oreja (Madrid) must be of "*piedra berroqueña*" (granite stone) from Las Ventas con Peña Aguilera (Baltanas 1998: 36-37). The distance between the quarry and the mill is about 100 km. It is interesting to note that these stones were chosen over the local Colmenar de Oreja white limestones (see M-2). A third reference is a report drawn up by two citizens in 1821, presented to the authorities in Madrid concerning the ownership, boundaries and qualities of the terrain population and administration of 16 towns in the Mountains of Toledo (Lopes & Martinez 1821). For Las Ventas con Peña Aguilera the report states that it has the best granite quarries of the Province of Toledo and that, besides the construction material for the principal buildings, the quarries produce millstones for mills spread out over the whole of the province (López & Martínez 1821: 17-18). A last reference, published shortly after third, is in a geographical dictionary and echoes that the town has many granite or "*berroqueño*" quarries that supply millstones beyond the distance of 30 leagues (between 120 and 210 km) (Miñano 1828, Vol. 9: 286).

It is worth noting that several decades later, Madoz records many granite quarries but does not mention millstone production.

Toponymy: There are many place names spread across the municipality related to granite outcrops (*Berrueco*, *Cantos Blancos*, *Cantera*...). None, however, can be directly related to millstone production.

The quarry: The whereabouts and the type of exploitation (surface blocks, quarries) are not known. A modern granite exploitation, possibly hiding older workings, is 1 km north of the town at the place name *Berrueco*.

The granite industry is still an important economic activity in the town (Google Maps Street View).



Extract from geological map 648 (IGME) The quarry is in a granite unit (red with small white crosses). The darker horizontal bands are porphyric granite dikes.

Transport and distribution: This is one of the rare sites with information from old written sources related to the question of the millstones export. Three of the 19th-century reports coincide that Las Ventas con Peña Aguiler supplied millstones beyond local and regional needs, up to a distance up of about 165 km. The oldest text (1576) stresses that the stone was the best in all of Spain, suggesting also that it was widely distributed.

Dating: The site spans the Modern to Contemporary periods.

Rock type: Granite (Geological map 684 Navahermosa, 1990).

Source

Photograph of the Cerro del Águila: https://ssl.panoramio.com/photo/55252564 [accessed November 12, 2012].

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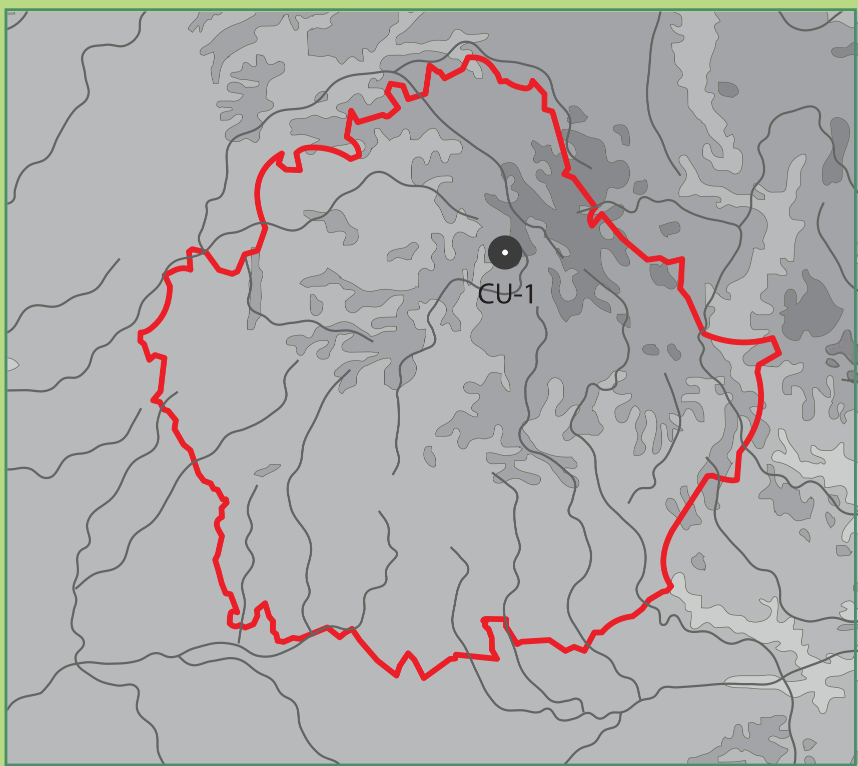
CASTILLA LA MANCHA

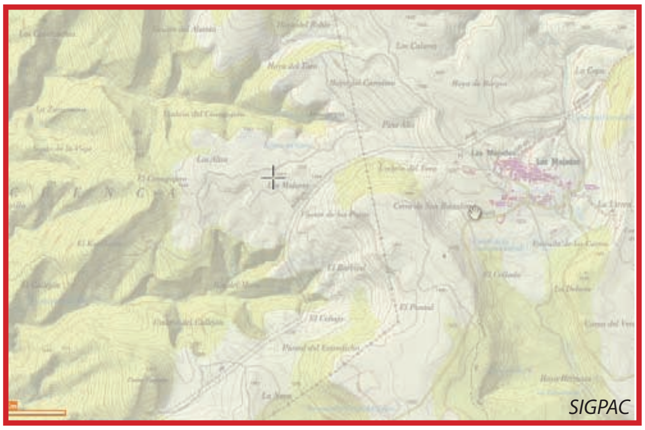
CUENCA (CU)



CU-1 Portilla

Los Molares

Latitude: 40º 17′ 54.32″ N
Longitude: 2º 2′ 44.08″ W
Altitude: 1350 m



View of the quarry (from the website CampiSierra:: http://www.campisierra.org/portal/lang__es-ES/p28615__2/tabid__11980/default.aspx).).

Abandoned millstone at the quarry (from the website CampiSierra).

Abandoned millstone at the quarry (from the website CampiSierra).

Location: The only millstone quarry identified to date in the Province of Cuenca is halfway between the towns of Portilla and Las Majadas.

Source: The site is described in the hiking itinerary posted on the internet (PR-CU 30, Serranía de Cuenca - Ruta del Gollizno y de Las Canteras - Portilla; see source) at an altitude of 1350 m. This is, for the moment, the highest site identified in our survey.

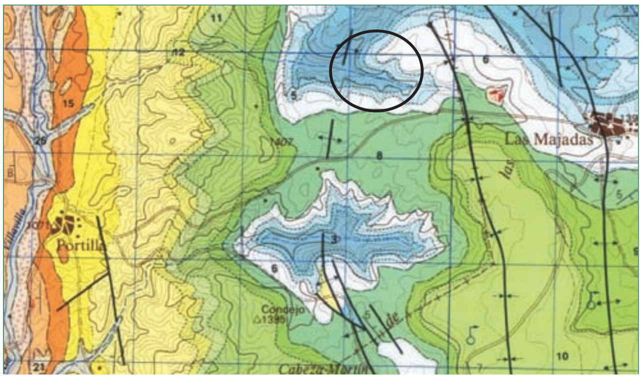
Toponymy: *Molares*, deriving from the Latin "*mola*", is the place name *par excellence* indicating millstone workings.

The quarry: Based on the photograph, the site appears to be a bench quarry at which millstones were hewn from previously detached slabs.

Product and dating: With the exception of the photographs, there is no data available about the production of the site. The millstones appear to be large models (about 1 m in diameter) probably for water-mills. The site could therefore date from Medieval to Contemporary times.

Transport and distribution: The hiking path that passes by the quarry is probably the same road used to transport the old millstones. This isolated site probably supplied local mills.

Rock type: From the geological map the rock is a dolomite rock or limestone (Geological map 587, Las Majadas, 1986). From the photographs, however, the rock appears to be a conglomerate with pebble clasts.



Extract from geological map 587 (IGME). Dolomite rock and limestone (blue).

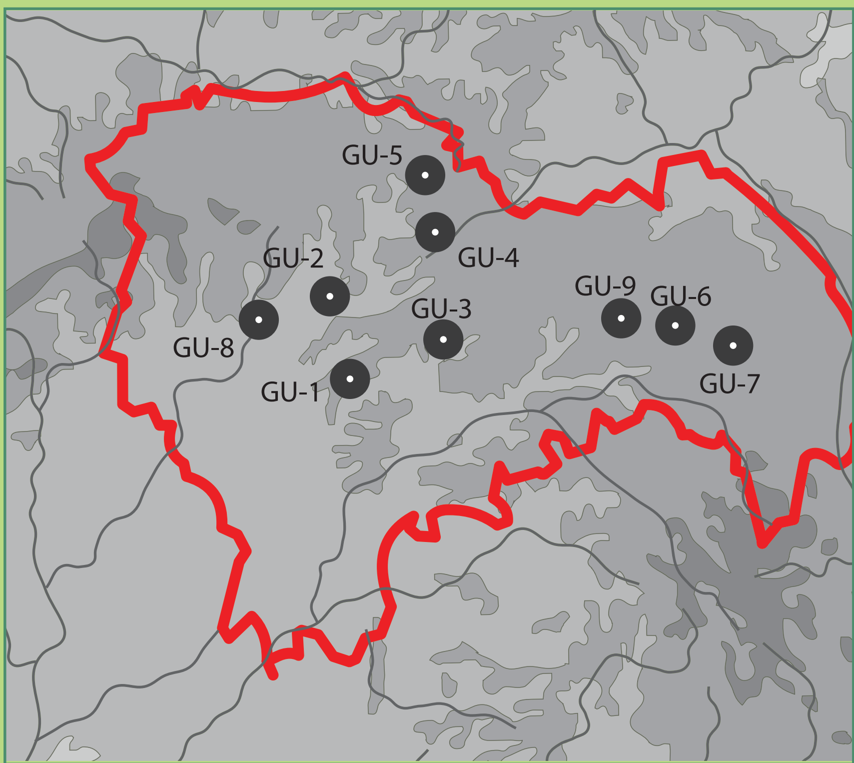
Sources

http://www.senderosdecuenca.org/Portals/111/senderos_pdf/PR_30_sierraAlta.pdf [accessed November 2, 2012].

Photographs from "CampiSierra": http://www.campisierra.org/portal/lang__es-ES/p28615__2/tabid__11980/default.aspx [accessed November 2, 2012].

CASTILLA LA MANCHA

GUADALAJARA (GU)



GU-1 Brihuega

Location and source: The Municipality of Brihuega is divided roughly into two main geographical areas: a high plateau to the northwest and mountains to the southeast. A "pumice" millstone quarry is recorded in a 19th-century treatise on the subject of hydraulic power (Vallejo 1833: 387). Its location, however, is not specified.

Toponymy: A place name *El Molar* in the cadastre (*SEC*) is about 3 km east of Brihuega, whereas the name *Pedrero* (quarryman) is 3 km to the southwest. Both of these names coincide with limestone tufa "pumice" outcrops and are potential locations of the quarry.

Extract from the cadastre (SEC) with the location of the place name El Molar.

Product and quantification: The treatise on hydraulic power states that Brihuega millstones can grind for 16 hours a day and require dressing every four hours (Vallejo 1833: 387).

Bread: Vallejo (1833: 387) records that the Brihuega stone yielded a flour as white as that of millstones from Colmenar, a reference to the site of Colmenar de Oreja in Madrid (M-2).

Dating: First half of the 19th century.

Rock type: The term "pumice" suggests a porous limestone tufa, a type of outcrop that is east and southwest of the town (Geological map 511, Brihuega, 1984; 512, Cifuentes, 1989).

Extract from geological maps 511-512 (IGME). Limestone tufa outcrops are units 17 and 21.

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GU-2 Pinilla de Jadraque

Monasterio de San Salvador

Latitude: 41º 2’ 2.93” N
Longitude: 2º 56’ 39.40” W
Altitude: c. 860 m

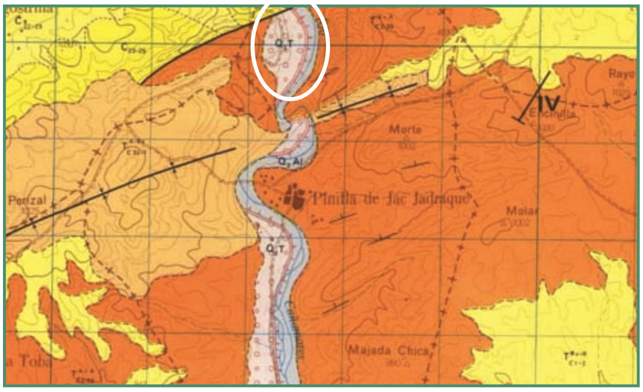
Location: This millstone quarry is reported to be 1,5 km north of Pinilla de Jadraque (also known as *Pinilla de las Monjas*) along the Cañamares River. It is commonly called the "Monastery of the Nuns".

Sources: The geographer Miñano specifies that "very good" millstones are extracted from this "beautiful quarry" (Miñano 1827, Vol. 4: 24).

An old geological treatise seconds the existence of the quarry and states that its millstones were hewn from "hard rock, like those of "Tobes" (see GU-5) (Castel 1881: 157-158).

Transport and distribution: Miñano indicates that these millstones were commercialised to the surrounding towns (Miñano 1827, Vol. 4: 24). This would seem to indicate a local sphere of commercialisation.

Rock type: The stone "near Tobes" is a presumably a *toba* (limestone tufa). This coincides with the description in the old geological study (Castel 1881: 22) and the geological units to the north of the town on geological map 460, Hiendelaencina, 1980.



Extract from geological map 460 (IGME). The rock type is tufa limestone according to the handbook of the Geological map.

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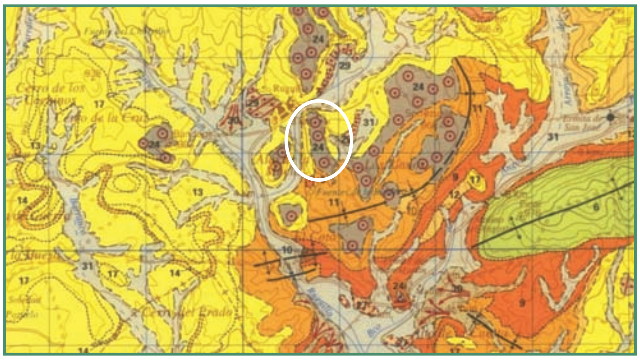
GU-3 Cifuentes
Ruguilla

Location and source: Ruguilla is a small town surrounded by mountains 5 km southeast of Cifuentes. The quarry is noted in a hiking itinerary posted posted by Oscar Quirós on the internet. It is located approximately to the south of Ruguilla in the direction to El Bujedal.

The quarry: The itinerary describes a quarry with extraction hollows and abandoned millstones in different stages of manufacture. Unfortunately the website is not accompanied by photographs.

Product, quantification and dating: Quiros indicates there are dozens of enormous and heavy extractions, suggesting an exploitation of large millstone dating from Medieval to Contemporary times.

Rock type: limestone, according to Quiros. The geological map 512 shows units of limestone tufa in the area identified by Quiros.



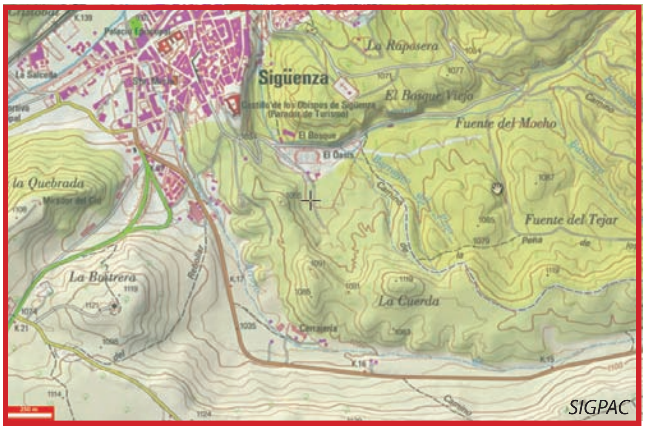
Extract from geological map 512 (IGME). The probable source is limestone tufa (brown with circles, 24). The rock could also be one of several varieties of sedimentary stones (yellow or orange).

Source

Oscar QUIRÓS. "Ruguila: El Aroma del Silencio": http://loscuadernos-deoscarquiros.blogspot.com.es/2007_12_01_archive.html [accessed November 12, 2012].

GU-4 Sigüenza

La Cuerda



Location: The site is about 2 km southeast of Sigüenza at the place name "*La Cuerda*".

Source: The quern is identified in a website dedicated to the history of the town of Siguenza.

Toponymy: The toponym *La Cuerda* in northern Spain coincides with several millstone quarries (Pascual & García 2011: 286). In our study area, however, this name does not seem to be a reliable indicator of these quarries.

The quarry and techniques: This appears to be a isolated extraction, possibly a "prospection" site, to test the quality of the outcrop. Multiple diagonal lines on the extraction face point to the pick as the tool to cut the trench. To facilitate splitting, the millstone maker profited from the edge of the rock layer to attain the base of the cylinder.

Product and quantification: The millstone extracted probably measured about 1,00 m in diameter. The author only mentions a single extraction hollow. This suggests a very local, isolated exploitation.

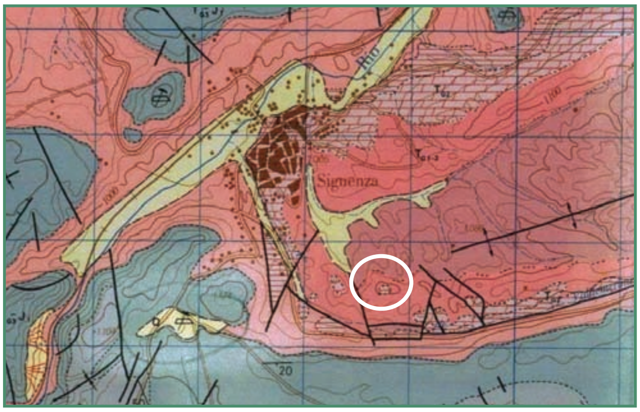
Dating: The extraction could date from Medieval to Contemporary times.

Rock type: According to the geological map the rock is a dolomite or sandstone (Geological map 461, Sigüenza 1978). From the photographs it appears to be a conglomerate with pebble clasts.

View of Sigüenza from the south, the approximate location of the quarry (photograph by Marcos Nieto, from Histgueb website: http://www.histgueb.net/minas_petroleo/lazona.htm).

View of the single millstone extraction along the edge of an outcrop (photograph by Marcos Nieto, Histgueb website).

Details of isolated extractions (photograph by Marcos Nieto, Histgueb website).



Extract from geological map 461 (IGME). The potential sources are dolomite (pink hatched) or sandstone (pink).

Source

Histgüeb, "Paseando entre antiguas minas": http://www.histgueb.net/minas_petroleo/lazona.htm [accessed November 2, 2012].

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Acknowledgements

I thank the historian Marcos NIETO for information and photographs of the site.

GU-5 Sienes

Tobes

Latitude: 41º 11'36.36" N
Longitude: 2º 39'41.51" W
Altitude: c. 980 m

Semi-circular stones (possibly millstone segments) used as window frames in the abandoned hamlet of Tobes (photographs by Faustino Calderón http://lospueblosdeshabitados.blogspot.com.es/2010/05/tobes-guadalajara.html).

Location and sources: The hamlet of Tobes, now abandoned, is 1 km southwest of Sienes. The millstone quarry is identified both in a 19th-century geological treatise (Castel 1881: 158-159) and in a website. From the sources it appears that the quarry is adjacent to the hamlet.

Toponymy: The name *Tobes* is probably a derivation of "*toba*", meaning limestone tufa. According to a geological study, the town is built on a thick stratum of this rock (Castel 1881: 158). The website indicates the presence of the place name *Molares*, typical for millstone quarries. This name, however, has not been confirmed either on the geographical map or on the cadastre. To the northeast of the town, the name *Moralejo* might be related to the millstone workings.

Dating: The geological treatise places the site in the second half of the 19th century.

Rock type: The geological map indicates conglomerate as the dominant rock (Geological map 434, Barahona, 1978). According to Castel, however, the rock is a hard limestone tufa (Castel 1881: 158).

Extract from geological map 434 (IGME). Conglomerate (in beige)

Source

http://www.pueblos-espana.org/castilla+la+mancha/guadalajara/tobes/ [accessed November 12, 2012].

Faustino CALDERÓN: http://lospueblosdeshabitados.blogspot.com.es/2010/05/tobes-guadalajara.html [accessed November 12, 2012].

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GU-6 Corduente

Location and source: Corduente is a large municipality (232 km2) in the Gallo River Valley in the Natural Park of the Alto Tajo. Madoz records that Corduente has quarries of "good millstones" (Madoz 1847, Vol. 7: 9). The writer, unfortunately, provides no other data as to the location of the site or the type of rock.

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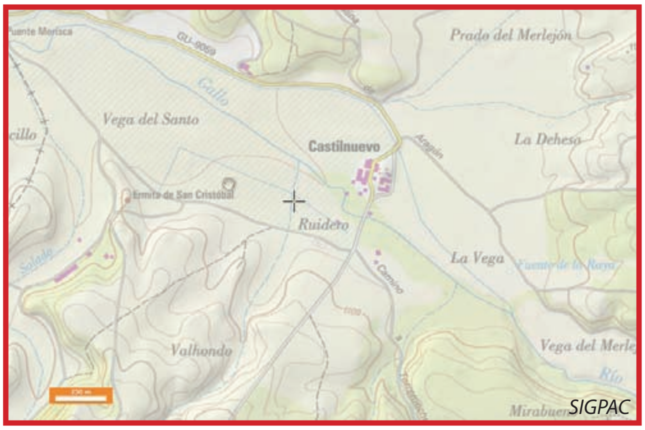
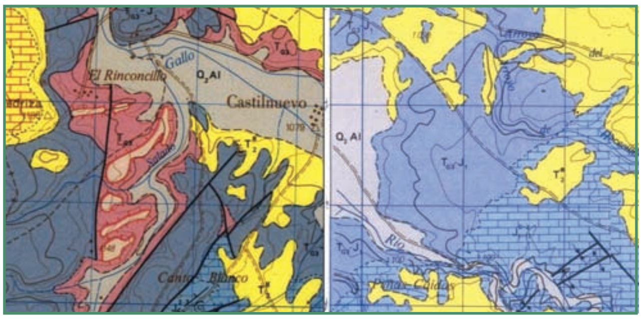
GU-7 Castilnuevo



Location and source: The Municipality of Castilnuevo, on the banks of the Gallo River, is very small (less than 20 km2). Madoz cites several millstone quarries of "*piedra tova*" (tufa limestone) that supply stones to the flour mills of the area (Madoz 1847, Vol. 6: 172).

Dating: First half of the 19th century, based on the text of Madoz.

Rock type: According to the geological maps, there are no limestone tufa outcrops in the surroundings of Castilnuevo (Geological map 514, Taravilla 1980; Geological map 515, El Pobo de Dueñas, 1979). The rock referred to by Madoz could turn out to be a rough limestone, a rock that is common to the surroundings of Castilnuevo.



Extracts from geological maps 514 and 515 (IGME). There are no "toba" (limestone tufa) outcrops in the surrounding of Castilnuevo. The quarries are probably to be found in the blue limestone units.

Bibliography

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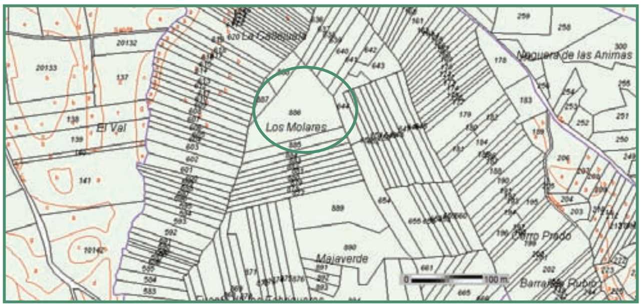
GU-8 Montarrón

Los Morales (Los Molares)

Latitude: 40º 54' 28.32" N
Longitude: 3º 6' 25.13" W
Altitude: 877 m

View from the northwest of the Cerro del Prado promontory outside of Montarrón. The place name Los Morales is on the northern edge of the hill *(Google Maps Street View).*



Detail of the cadastre with place name Los Molares (SEC).

Location and source: The millstone quarry is perched on the northern point of the Cerro del Prado promontory, above the town of Montarrón. It is recorded in Response 24 of the *Royal Census of Philip II* (1574-1578) and specifies that it is an exploitation of "*piedras arineras*" (flour millstones). According to a study of the Medieval constructions on the hill, there are abandoned millstones in different stages of manufacture (Pavón 1984: 92).

Toponymy: This site's name illustrates perfectly the problem of the inversion of the syllables "r" and "l" in the case of *Los Morales* and *Los Molares*. In the geographical map (SIGPAC), the name is written *Los Morales* (meaning the "mulberry trees"), whereas in the cadastre (SEC) it is *Los Molares*, from the Latin *mola* (millstone), typical of millstone quarries.

It is worth noting that there are several toponyms related to iron working, such as *Las Fraguas* (the Smithies) and *Las Herraduras* (the Horseshoes) on the hill. It cannot exclude that these iron working names reflect a work related to the maintenance of the quarry tools.

The quarry: From Pavón's description, we have the impression that millstones were hewn from detached angular blocks.

Products and dating: Pavón records that two millstones models were made at the site. Unfortunately the exact dimensions of each model are not mentioned. Large pieces, presumably water millstones, were hewn from "enormous blocks" (Pavón 1984: 92). Their dating is not certain (Medieval to Contemporary). The smaller models could be older medium-sized millstones or hand-querns (Pavón 1984: 92). The dating of the models remains obscure.

Rock type: Sandstone, conglomerate or limestone (Geological map 486, Jadraque, 1983).

Extract from geological map 486 (IGME). The red unit (18) includes sandstones, conglomerates and limestones.

Source

Relaciones Topográficas de los Pueblos de España de Felipe II, 1574-1578. Montarrón: http://www.uclm.es/ceclm/b_virtual/libros/relaciones_gu/MONTARRÓN.htm [accessed November 17, 2012].

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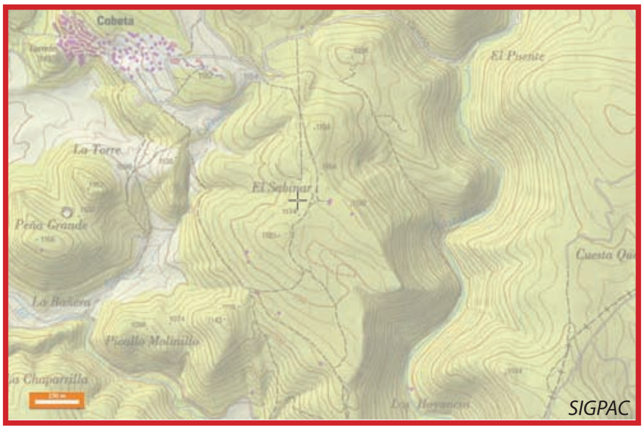
GU-9 Cobeta

Barranco de Arrandilla

Latitude: 40º 51′ 46.55″ N
Longitude: 2º 7′ 55.83″ W
Altitude: 1140 m



Location: The site is on the outskirts of Cobeta in the Natural Park of the Alto Tajo.

Source: The site is identified in a geological guide of the National Park (Carcavilla *et al*. 2008: 143).

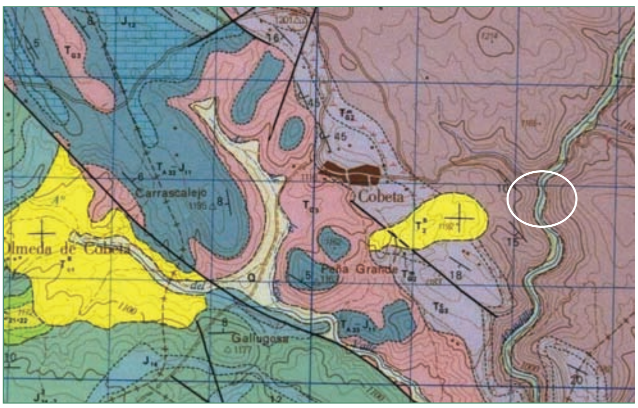
The quarry: The photograph shows a true extractive quarry with multiple, contiguous extraction hollows.

The product: The cylinders in the photograph measure c. 80 cm in diameter. Although millstones are known to have been extracted from reddish sandstone (see Montoro, C-14), the examples in the photograph could also be sharpening stones.

Dating: Without knowing the true nature of these products, it is not possible to propose a date.

Rock type: Red sandstone (Geological map 489, Molina, 1979).

View of the quarry with cylinders measuring c. 80 cm in diameter. The extractions, from their size and stone type, are probably sharpening stones (from Carcavilla et al. 2008: 143; http://es.scribd.com/doc/48886123/GUIA-P-N-ALTO-TAJO-I-carcavilla-total).



Extract from geological map 489 (IGME). The quarry is in the red sandstone unit (purple) to the east of Cobeta.

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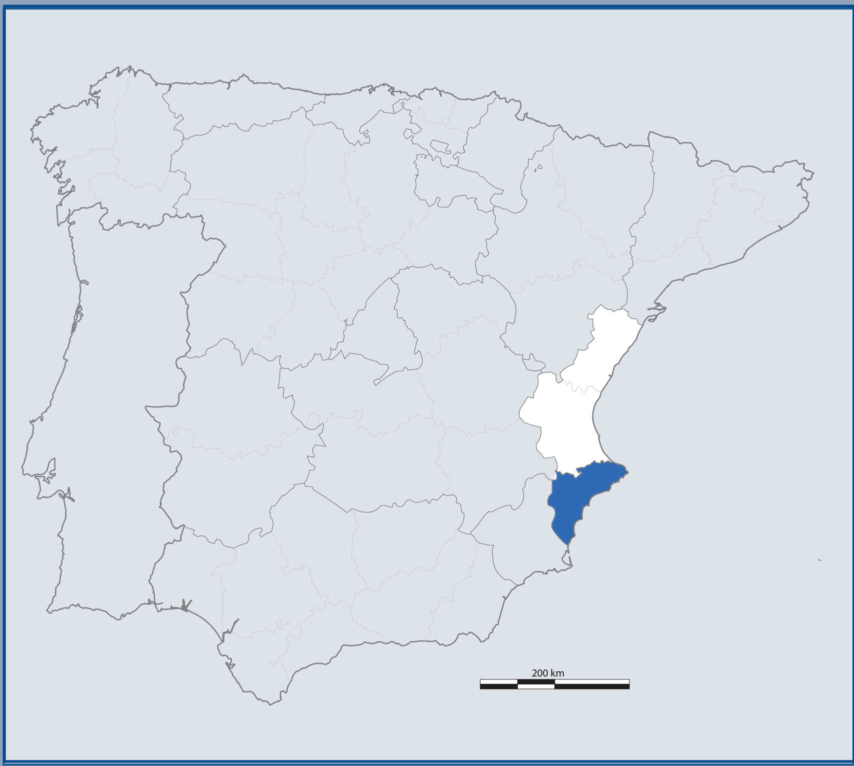
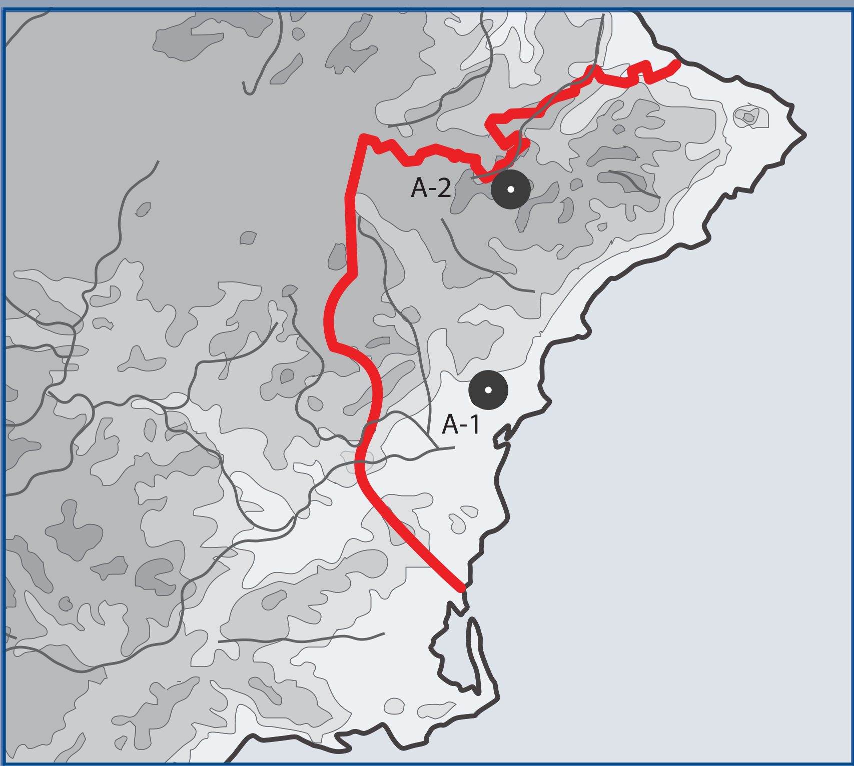
VALENCIA

ALICANTE (A)





A-1 San Fulgencio

Sierra del Molar

Latitude: 38º 7’ 32.95” N
Longitude: 0º 39’ 46.38” W
Altitude: c. 20-50 m

SIGPAC

Location and generalities: The *Cueva de los Cochinos* (or *Marranos*, meaning swine) is at a low mound called *Sierra Molar* beside Marina-Oasis, an urbanisation on the Segura coastal plain, less than 2 km from the Mediterranean coast. In spite of the term “cave” (cueva), there is no indication that the site was a subterranean quarry.

Sources and toponymy: The site is first recorded in an archaeological inventory of the Elche Municipality. The author associates the *Molar* toponym with millstone working (Ramos 1953: 347). A more recent archaeological field survey backs up the notion of a millstone quarry but does not furnish concrete evidence (Gutiérrez *et al*. 1999, 38).

The quarry: Nothing remains today of the possible quarry owing to the modern exploitation of cement (Gutiérrez *et al*. 1999: 38).

Dating: The date of the site is unknown.

Rock type: Sandstone or calcarenite (Geological map 914, Guardamar del Segura, 1972).

Orthophoto of the modern cement exploitation that has destroyed the site (SIGPAC).

Extract from geological map 914 (IGME). Sandstones and calcarenites (yellow).

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RAMOS FOLQUES, Alejandro. Mapa Arqueológico del Termino Municipal de Elche (Alicante), Consejo Superior de Investigaciones Científicas, Instituto de Arqueología y Prehistoria “Rodrigo Caro”, Madrid. 1953, p. 323-354.

A-2 Ibi

Barranco de los Molinos

Latitude: 38º 38' 29.60" N
Longitude: 0º 34' 44.12" W
Altitude: c. 900 m

Location: This quern quarry, 1,5 km north of Ibi, is organised in two different sectors over 100 m apart on opposite slopes of the *Barranco de los Molinos* (ravine of the mills).

Sources and toponymy: The site is briefly noted in an article by Á. Marquiegui on the old hydraulic works (watermills, fulling mills) in this valley. Otherwise it is not mentioned in any old written sources. Its name derives from the series of Modern and Contemporary mills in the valley and has no relation with the ancient quarry.

The quarry and techniques: The site is an extensive shallow surface quarry comprising numerous contiguous hollows. Extraction took place on a very inclined, at times almost vertical, plane, obliging quern makers probably to adopt some kind of scaffolding. Working debris would have naturally tumbled downhill. Due to extreme weathering, tool marks are poorly visible.

Product and quantification: The production, in the hundreds, is limited presumably to querns about 40 cm in diameter.

Distribution: This site probably served the needs of local settlements.

Dating: The site could date anywhere from the Late Iron Age to Medieval times. The scale of the production would lean the balance toward a Roman date. An earlier Iron Age (Iberian Culture) date, on account of the ratio diameter/thickness of the cylinders, cannot be discounted. For the same reason, a Medieval date is less likely.

Rock type: Limestone or dolomite rock (Geological map, 846, Castalla, 1977). The quarrymen exploited a specific limestone layer with a rough aspect and intentionally avoided a finer, homogenous (probably less abrasive) adjacent limestone stratum (pers. comm. from Á. Marquiegui).

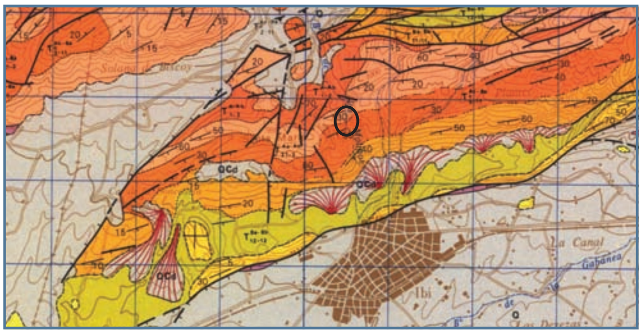
View of the western sector of the quern quarry (photograph by José Lajara).

View of part of the eastern sector of the quern quarry (photograph by José Lajara.)

View of part of the eastern sector (photograph by José Lajara).

Detail of a quern extraction (photograph by Ágata Marquiegui).

Detail of contiguous extraction hollows of small rotary querns (photograph by José Lajara).



Extract from geological map 846 (IGME). The quarry is in a limestone and dolomite units (light orange).

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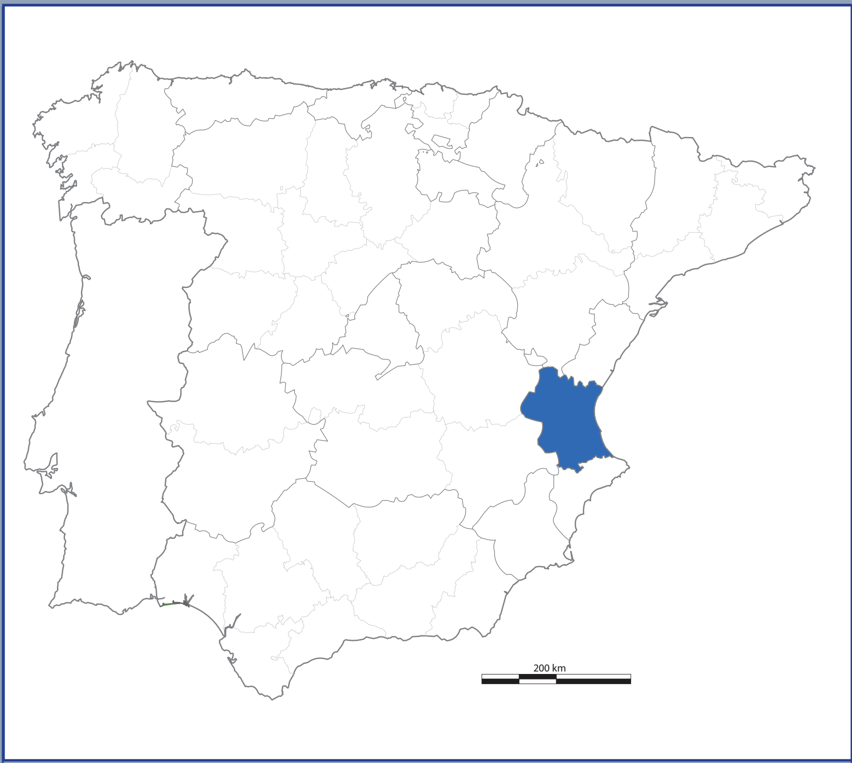
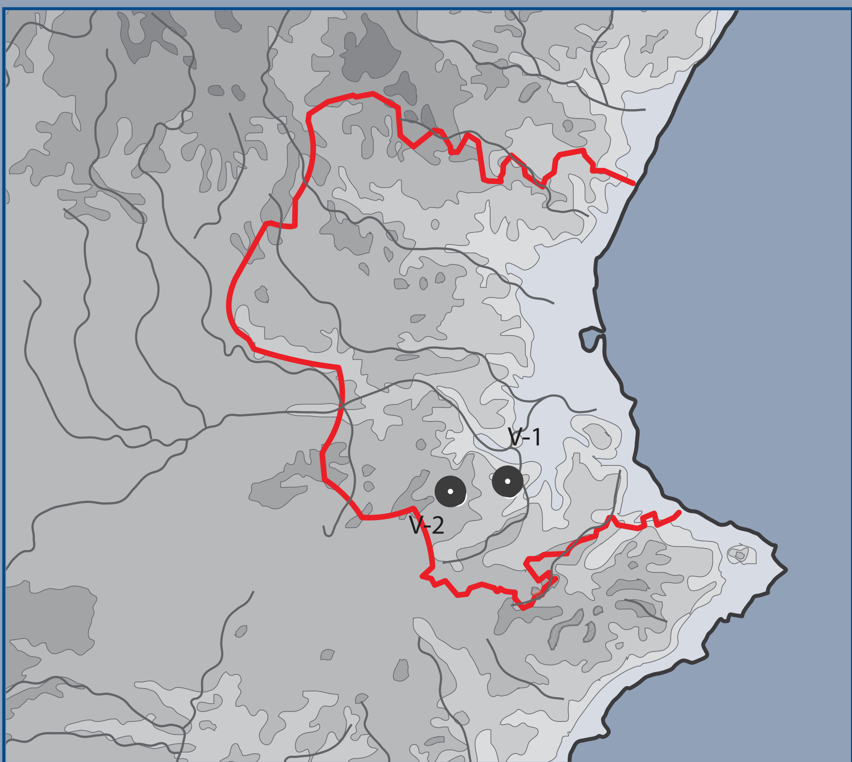
Acknowledgements

The information of this site comes from the historian Ágata MARQUIEGUI SOLOAGA and the archaeologist José LAJAR MARTíNEZ. The photographs are the property of José LAJAR MARTíNEZ. I sincerely thank them for their assistance.

VALENCIA
VALENCIA (V)





V-1 Canals

Les Moles

Latitude: 38º 56 49.23" N
Longitude: 0º 36' 0,42" W
Altitude: c. 150 m

Location: The millstone quarry of *Les Moles* is the riverbed of the Canyoles River southwest of Canals.

Source: The site is recorded in the website of the Municipality of Canals.

Toponymy: *Les Moles,* deriving from the Latin *mola* (mill), appears as the name of a town house, a local road and an industrial quarter southwest of the town. 2,5 km farther southwest is *Els Canteressos*, possibly deriving from *cantera* (quarry).

The quarry, products and quantification: The site appears to be between a pit and a pocket quarry, with hollows corresponding to cylinders over a metre in diameter.

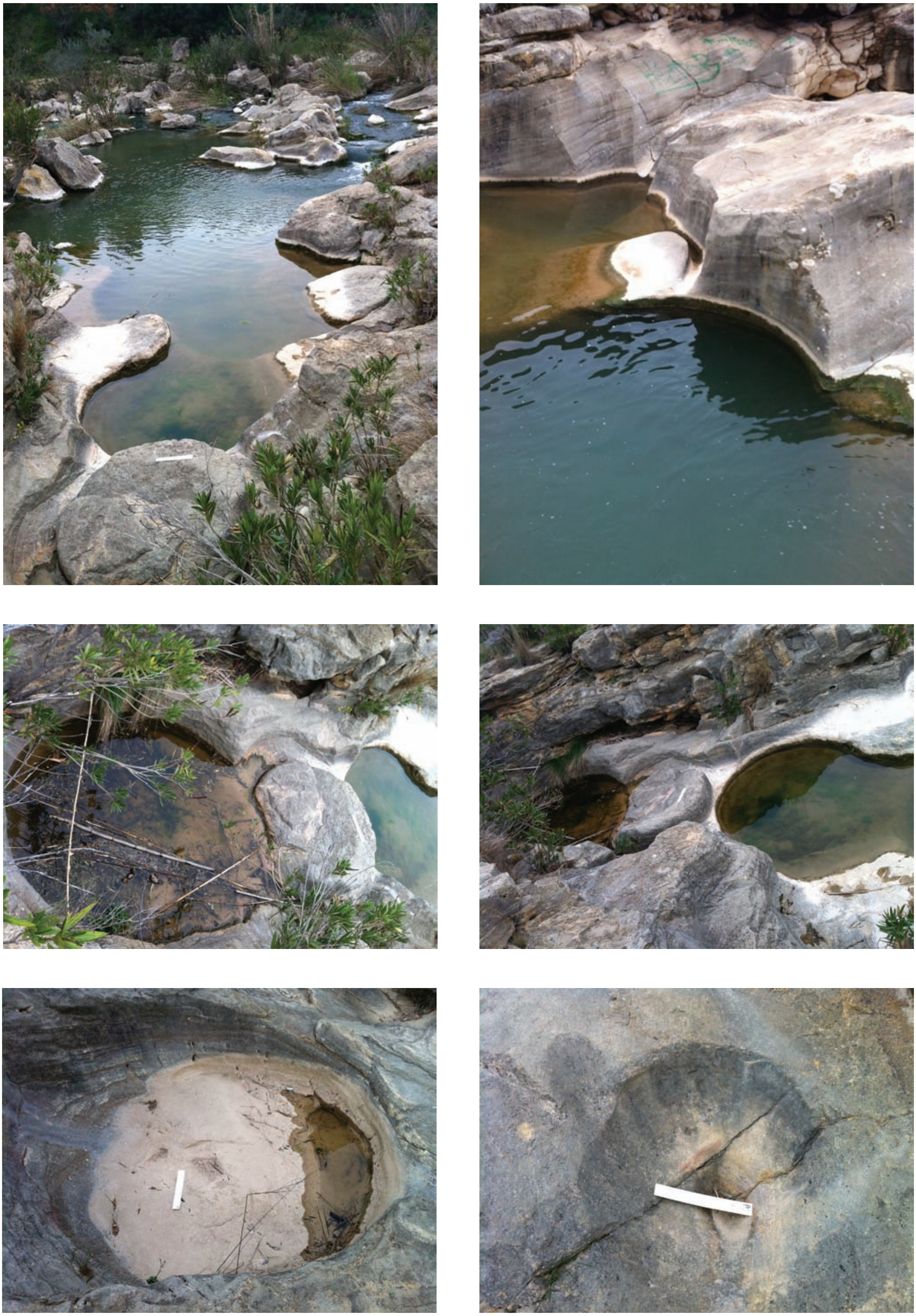
Distribution: According to A. Polop, the site is modest. It therefore must have supplied only the local mills.

Dating: Medieval to Contemporary.

Rock type: Limestone (Geological map 794, Canals, 1976).

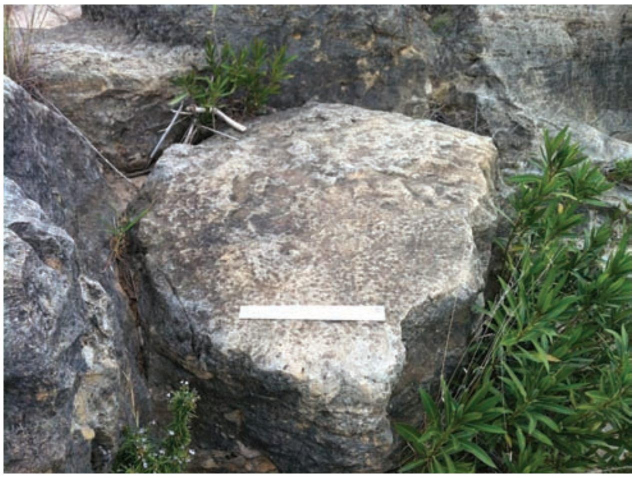
View of the Canyoles River (from Google Maps Street View).

View of the quarry (photograph by Juan García Cerdá).



Different views of the Canals quarry. The white ruler is 30 cm long (all photographs by Juan García Cerdá).

Views of an abandoned cylinder (photograph by Juan García Cerdá).



Views of a broken cylinder (photograph by Juan García Cerdá).

Extract from geological map 794 (IGME). The rock corresponds probably to a unit of limestone.

Source

Website of the Municipality of Canals: http://www.canals.es/canals/index.php/ciudad/paisaje.html [accessed November 22, 2012].

Acknowledgments

I thank José Antonio POLOP of the Town Hall of Canals for general information about the site and Juan GARCÍA CERDÁ for the photographs.

V-2 Montesa

La Mola

Latitude: 38º 57’ 5.89” N
Longitude: 0º 39’ 9.62” W
Altitude: c. 340-380 m

Location: The millstone quarry at Montesa is spread out along the southern flank of the *Mola* plateau, from the fortification to the east, to the crag to the west, today a haven for rock climbers.

Source: Circular extraction hollows are described in an anonymous travel blog on the internet. The website, however, does not identify them as a quarry.

Toponymy: The name *La Mola*, from the Latin *mola* (millstone), in the Valenciano language, designates, as is the case here, a hill with a flat top.

The quarry: Extraction hollows, according to J. García Cerdá, are spread out in different sectors. To the east is an edge quarry comprising superimposed extractions forming a high, tubular quarry face that today reaches the foot of the castle. Other extractions are isolated or clustered in benches.

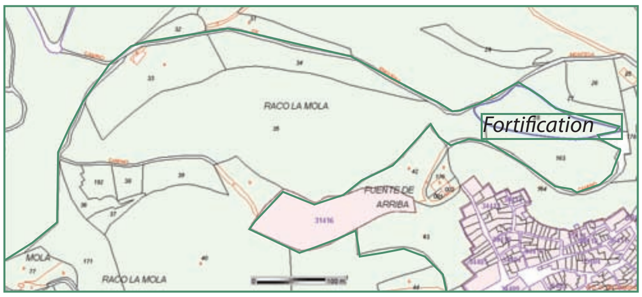
Product, quantification and distribution: Based on the photographs, we deduce that both rotary querns (around 50 cm) and millstones (over a metre in diameter) were scored. Medium-sized extractions are also possible. The number of extractions is difficult to estimate. The impression, however, is that of a production destined to regional mills.

Dating: The sizes of the smaller quern extractions suggest a Medieval, or possibly Roman, date. The stratigraphical relationship between the tubular edge quarry and the foundations of the fortification is not clear. We doubt, for reasons of stability, that extraction would have been permitted if the foundations were already in place. It is thus likely that the quarry is older than the fortification which has its origins under the Islamic domination (Guichard 2001: 248). The larger extractions elsewhere on the hill could range from Medieval or Contemporary times.

Rock type: Bioclastic calcirudite (Geological map 794, Canals, 1974).

View from the south of the Mola *hill northwest of Montesa (Google Maps Street View).*

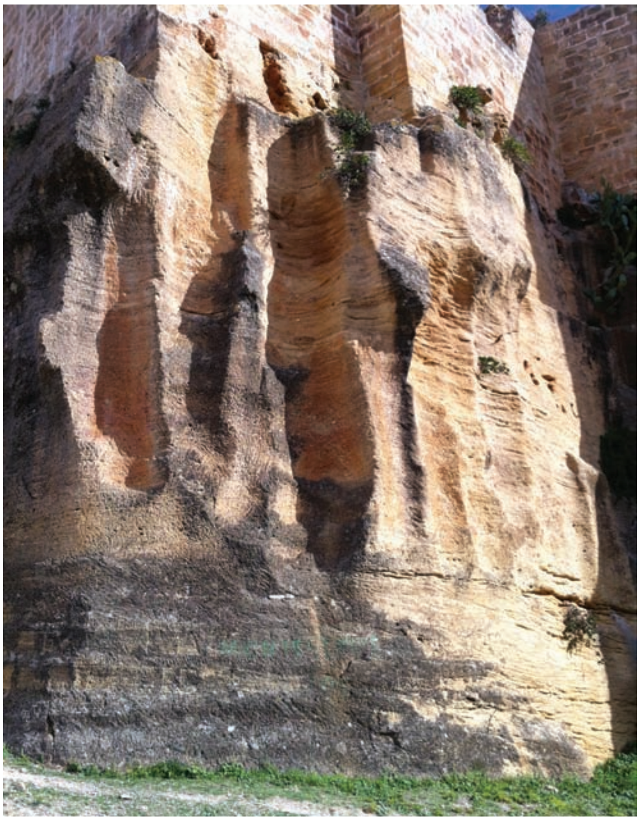
Aerial view of the Montesa plateau and castle (to the right) (SIGPAC). The arrows indicate the exploited areas.



Extract of the cadastre (SEC). The place name mola *is at the area on the top on the slopes of the plateau, as well as at the parcels of the fortification (28, 163, 164).*

View of the tubular quarry face at the base of the western perimeter of the Castle of Montesa (from Google Maps Street View).

Isolated extraction hollow of a rotary quern measuring about 50 cm in diameter (photograph by Juan García Cerdá).

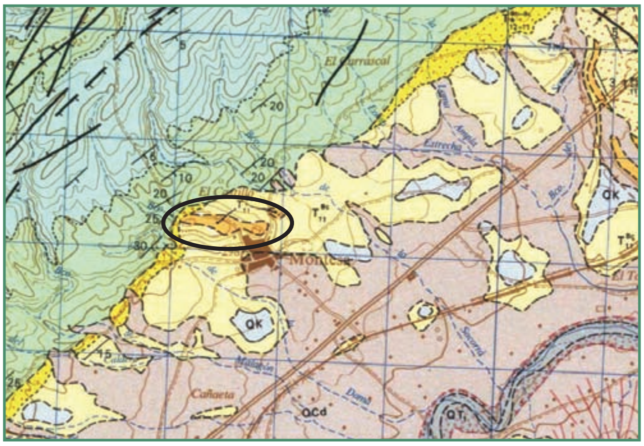


Detail of the edge quarry with vertical tubular extraction hollows at the base, and apparently cut, by the fortification (photograph by Juan García Cerdá).

View of a group of large extraction hollows on four levels (about 1 m in diameter (photograph by Juan García Cerdá).

Extraction hollow of a cylinder measuring approximately 1,10 m in diameter (photograph by Juan García Cerdá).

Extraction hollow of a cylinder measuring approximately 1,20 m in diameter (photograph by Juan García Cerdá).



Extract from geological map 794 (IGME). The quarry corresponds to the bioclastic calcirudite outcrop (orange). The surrounding unit (yellow) is loam.

Source

Anonymous travel blog "Montesa, Enclave Megalítico": http://viajesmagicosporiberia.blogspot.com.es/ [accessed January 7, 2013].

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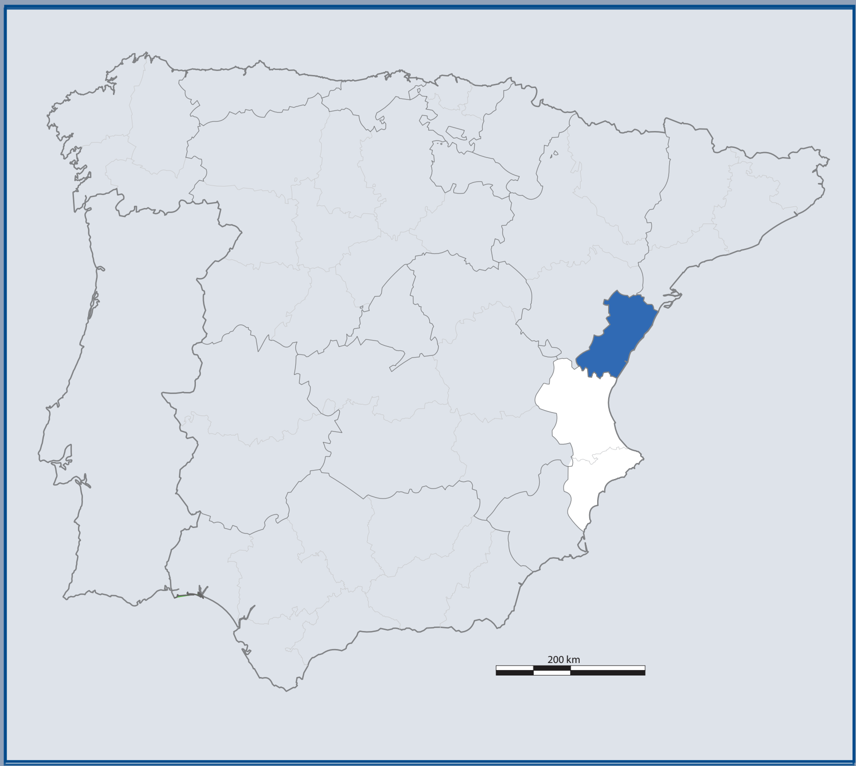
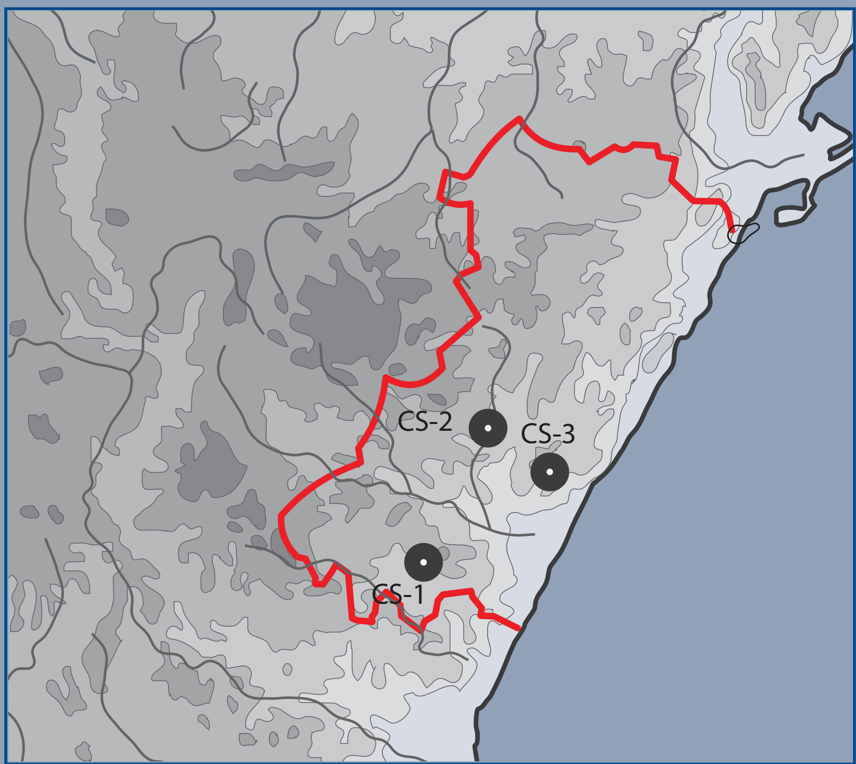
Acknowledgments

I sincerely thank Juan GARCÍA CERDÁ, the mayor of the town of Montesa, for the photographs and information about the site.

VALENCIA

CASTELLÓN (CS)





CS-1 Soneja

Los Arenales

Latitude: 39º 48′ 52.96″ N
Longitude: 0º 19′ 56.92″ W
Altitude: 460 m

Location: The *Arenales* millstone quarry is on the summit of a mountain in the Soneja Natural Park near the La Laguna de la Dehesa.

Sources: The site is mentioned briefly in an article about the mills of the Province of Castellón (Barberà 2003: 194). It is also included in several different hiking itineraries on the internet with a short video and photographs by D. Molina.

The quarry: The presence of angular blocks in the photographs suggests that millstones were fashioned from detached blocks.

Product, quantification and distribution: Large millstones for watermills or windmills. The site is modest and meant for local mills.

Dating: The diameter of the product suggests a dating ranging from Medieval to Contemporary times.

Rock type: Argillite or sandstone (Geological map 668, Sagunto, 1972).

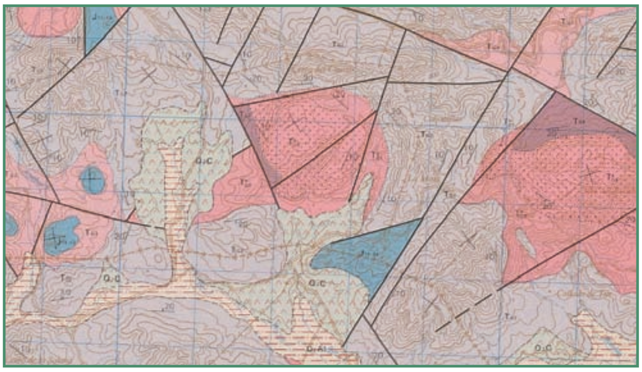
Orthophoto of the millstone quarry seen in the clearing of the forest near the hiking trail (SIGPAC).

View of the millstone quarry (photograph by David Molina).

View of an abandoned cylinder surrounded by working debris (photograph from blog "Andamontes" http://andamontesenblog.blogspot.com.es/2013/03/laguna-de-la-dehesa-paraje-natural.html).

Views of abandoned cylinders surrounded by working debris (from a Youtube video: http://www.youtubecomwatch?v=yFdj83OQTe0).

Examples of abandoned millstones in different stages of manufacture (photos by David Molina).



Extract from geological map 668 (IGME). The pink unit in the centre corresponds to sandstones.

View of the outline of a future millstone (from bhttp://bike-pedalvalencia.blogspot.com.es/2013/07/alfara-de-la-baro-nia-sot-de-ferrer.html).

Sources

Hiking itinerary: http://www.soneja.es/node/249 [accessed November 2, 2012].

Hiking itinerary "Andamontes": http://andamontesenblog.blogspot.com.es/2013/03/laguna-de-la-dehesa-paraje-natural.html [accessed April 21, 2013].

Short video on YouTube: http://www.youtube.com/watch?v=yFdj83OQTe0 [accessed November 2, 2012].

http://bikepedalvalencia.blogspot.com.es/2013/07/alfara-de-la-baro-nia-sot-de-ferrer.html [accessed September 24, 2013].

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Acknowledgments

The photographs are the property of David MOLINA. I kindly thank him for permitting me use them in this study.

CS-2 Lucena del Cid

Location and source: Lucena del Cid is a municipality (137 km2) in the central mountains of Castellón. Millstone production is cited briefly in the study of old mills in the Province of Castellón (Barberá 2003: 194). The author provides no other information about the site.

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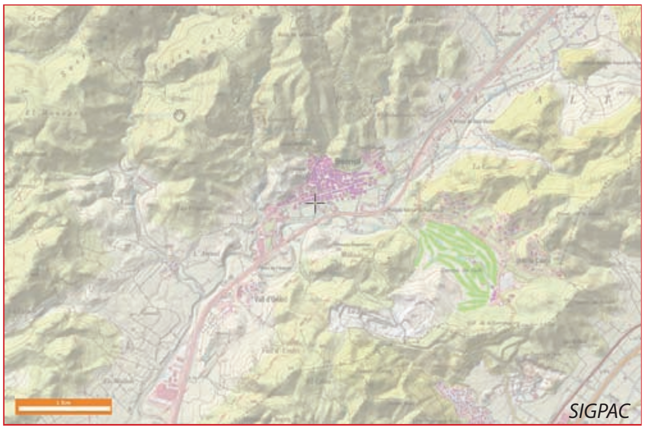
CS-3 Borriol



Location and sources: Borriol is a municipality of 62 km2 in southeastern Castellón in the Castellet Mountains. Millstone production is mentioned briefly in the study of old mills (Barberá 2003: 194). There are a number of potential quarries exploiting limestones or conglomerates in the municipality: Pedrera de l'Abeller, Pedrera Vella, Pedrera Morinbou and Pedrera de la Joquera (Allepuz Marzà 2003: 216-217). Millstone working, however, cannot be confirmed at any of these sites.

There absence of mention in the dictionaries of the 19th century suggests a modest site.

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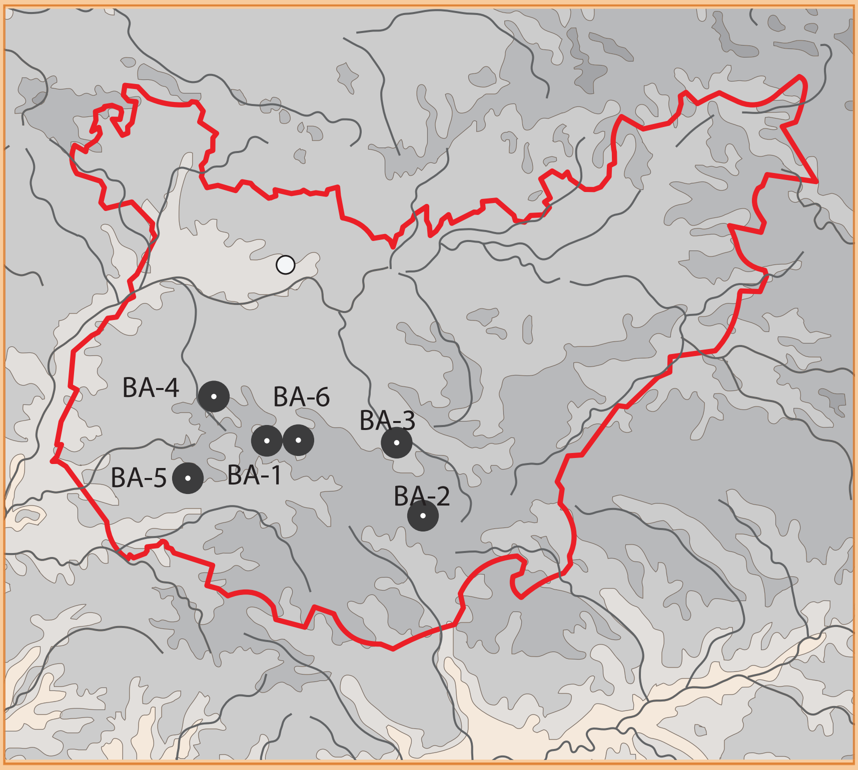
EXTREMADURA

BADAJOZ (BA)



BA-1 Alconera

Las Pedreras

Latitude: 38º 25' 1.12" N
Longitude: 6º 28' 47.32" W
Altitude: c. 470-500 m

Datos del Bien Inmueble	
Referencia catastral	06008A002000320000QU Obtener etiqueta
Localización	Polígono 2 Parcela 32 PEDRERAS. ALCONERA (BADAJOZ)
Clase	Rústico
Coeficiente de participación	100,000000 %
Uso	Agrario

Extract of the cadastre (SEC). Parcel no. 32 (surrounded by the blue line) corresponds to the place name Pedreras *(quarries).*

Location and sources: Alconera in the Sierra of Alconera in southern Extremadura. It enjoys a long tradition of limestone and breccia exploitation for construction material spanning from Roman (Padilla 1999: 278) to recent times (Gascón 1904: 381).

Millstone production in Alconera is reported in research by Caso Amador about the history of watermills of the south of Extremadura. It is set at the *Dehesa de Abajo*, 2 km north of Alconera at the foot of the Sierra Gorda (Caso Amador 2008: 132). This location coincides with a vast modern cement exploitation. In the cadastre (*SEC*) the name *Pedreras* (quarries) also appears here. Other rock exploitations both south and west of the town are noted on the geographical map. Their place names, however, evoke marble and quicklime workings.

Caso Amador (2008: 133) notes the responses related to millstone working from the Royal Census of 1791:

1: After describing the livestock and the absence of mineral exploitations, the survey cites quicklime and millstone production (specifying for flour mills).

2: The survey frets that the agricultural potential of the town is not exploited to its maximum because millstone makers and brick/tile makers neglect their duties in the field.

3: The survey repeats that the town's agricultural potential, although not important, is diminished by the neglect of the 162 souls who devote most of their time to brick/tile production and the prosperous "millstone factory".

4: The survey records that the stone yielded a white flour for bread.

A second written source alluding to millstone working from Alconera is the list of products penned by the Chief Engineer of Mines of Badajoz for the Universal Exposition of Paris (1867). The list itemizes limestone millstones at a cost of 16 to 20 *escudos* (Comisión Régia, *Catálogo* 1867: 182, entry 13-57).

Toponymy: The name *Pedreras* (quarries) is often associated with exploitations for construction material or millstones.

Dating: The Royal Census of 1791 dates the production to the second half of the 18th century. Although both of the 19th-century geographers Miñano and Madoz cite stone extraction around the town, they do not specifically mention millstone work. Nonetheless, the production must have endured - and even flourished - judging by the participation in 1867 at the Universal Exposition of Paris.

Dwelling: Several rock huts similar to the dwellings at the site of El Lachar, Jimena (JA-2) stood near the quarry. Unfortunately, these constructions, possibly temporary dwellings of the quarrymen, have been destroyed by the cement factory (Website Patrimonio del Pueblo).

Bread: The Royal Census of 1791 notes the Alconera stone yielded a white flour for bread (Caso Amador 2008: 133).

Rock type: Limestone (Geological map 854, Zafra, 1980). The term "*concha*" (shell) of the survey extract 4 suggests a sedimentary stone containing shells. The item from the Catalogue of the Universal Exposition of Paris confirms that it is a limestone.

Extract from the Responses to the Royal Census of 1791

Extract 1 : Concerning production of the town

"En esta villa ai cria de ganado de zerda en corto numero y su destino es engrosar para las matanzas de casa los nezesarios en otra jurisdizion por que aqui no ay montes, aunque pudiera aberlos como llebo espuesto. Ai tambien cria de ganado bacuno en mui corto numero, de modo que no basta para el uso de la agricultura; ai tambien cria de ganado lanar basto en mediano numero por tres ganaderos y lo mismo de cabras por otros tres y el numero de cabezas de todas espezies asziende a dos mil, poco mas o menos. ***No ai minerales algunos en esta villa, pero ai canteras de piedras de cal y de muelas para molinos de harina, de que se haze el huso correspondiente****" ....*

Extract 2: concerning agriculture

"Por lo que respecta a la agricultura aunque las tierras y suelo de este pais son de mediana calidad y estar cansadas con las continuas lavores, a motivo de no aver mas que dos ojas para semvrar por la cortedad del termino, no obstante si los vezinos tuvieran mas zelo en cultivarlas y benefiziarlas a tiempo, lograran maiores y mas sazonados frutos en toda especie de granos, ***pero con la favrica que avunda en este pueblo de piedras de molino y canteria de otra maior avundancia que lo es de ladrillo y teja, se olvidan de la lavores, asistiendo haltas, tarde, sin tiempo y tal vez sin cultivar las tierras con los barvechos nezesarios, por estar ocupados la mayor parte de jornaleros en estas favricas, motivo porque estan mui de cayda las lavores".***

Extract 3: concerning the population (from website)

"El termino de esta villa es proporcionado a su poblacion de 162 vecinos y seria mas productivo si hubiese caudales para hacerlo fructificar. Hai algunas tieras cercadas con malas cercas de piedra, las quales se siembran todos los años, cultivandose a dos hojas las que no están cercadas, cuya diferencia es una prueba de la ventaja de los cerramientos. Sus principales frutos son trigo, zebada, aceite y vino, sin haber sobrante para vender a no ser de trigo en años de cosecha abundante. Lo que se vende y es su comerzio activo son algunas almendras y sus buenas frutas, ***a cuyo dinero se agrega el producto de sus fabricas de ladrillo y texa, y de las estimadas piedras que sacan para molinos harineros, que es en lo que consiste toda la industria de este lugar".***

Extract 4: *concerning holidays and commerce*

"No se zelebran en esta villa ferias ni mercados, ni son nezesarios por estar una legua distante de la villa de Zafra, donde se zelebran a el año tres ferias y su gran comercio es un continuo abundante mercado, de donde todos los vezinos de esta villa se surten de todo lo nezesario sin mucho quebranto en ir a comprarlo. ***Ai trafico de sacar y cortar en algunos vancos de piedra, de la que llaman aqui de concha, muchas muelas para molinos de trigo de que resulta harina para poder sacar pan blanco, donde sepan azer el uso bueno que requiere; pero los // trabajadores en dicha piedra que no forman compañia, no la hazen de continuo por que en tiempo de la siega de mieses, o quando lo exije la atenzion de su propia sementera o cosecha, tienden a esta como negocio de primera nezesidad»***

(Extracts 1-3 from the website of the Alconera; extract 4 from Caso Amador 2008: 132-133)

Extract from geological map 854 (IGME). The reputed location of the millstone quarry. The light blue, representing limestone, is consistent with the rock mentioned in the old texts. The green (slates and greywackes) does not conform to the old texts.

Source

Website of the town of Alconera with the Royal Census of 1791: www.nuevoportal.com/andando/pueblos/extrema/badajoz/alconera.html [accessed October 25, 2012].

Website El patrimonio histórico y cultural de la comarca: http://www.nodo50.org/asierrasuroeste/patrimonio.htm [accessed October 25, 2012].

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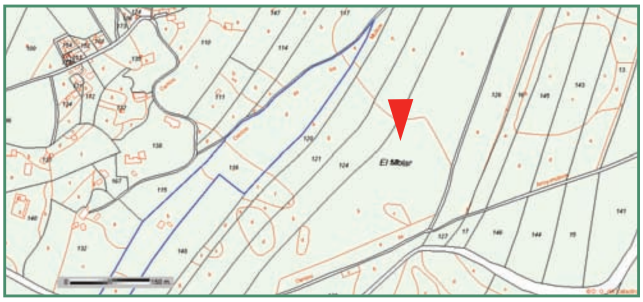
BA-2 Llerena

El Molar



Extract of the cadastre (SEC) with the place name El Molar.

Location: The millstone quarry of Llerena is in the flat lands near the Madrona Spring about 4 km southwest of Llerena.

Sources: The first record of the site is in a Municipal Ordinance dating to 1566 in which the authorities prohibit "foreigners" from extracting millstones unless they, like the locals, pay the official tariff (Chapter CXCVII of the ordinances; Maldonado Fernández internet website).

The Royal Census of Extremadura of 1791 also records a millstone quarry at Llerena that supplied stones to the mills of the surrounding area (Caso Amador, 2008).

Toponymy: The exploitation, according to a local historian Mena Cabezas, is at the place name *Molar,* from the Latin *mola* (mill) (Mena Cabezas 2001: 246). This name, although no longer conserved on the geographical map, is recorded on the cadastre. The author also denounces its deteriorated state (turned into a landfill) and solicits the local authorities to remove the refuse, excavate it and incorporate it into a project of valorisation with a series of other historical sites.

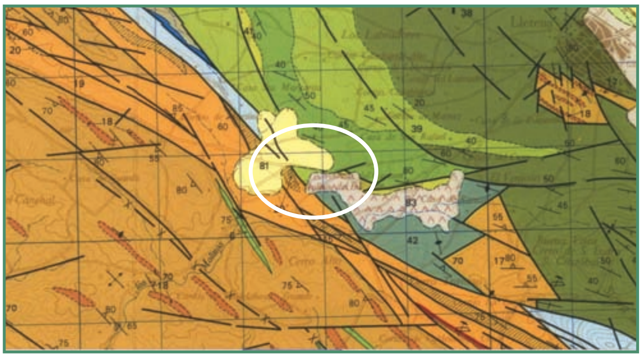
Dating: Production is certified by the written sources in the 16th century and at the end of the 18th century. It is conceivable that the site was exploited continuously between these two dates.

Rock type: Limestone, arkose and limestone tufa outcrops (Geological map 877, Llerena, 1981). The exact type of rock exploited is uncertain.

Extract from the Responses to the Royal Census of 1791

"No hay minerales ni canteras de marmol, jaspe, ni yeso, pero si para fabrica de cal y piedras de molinos de que se surten muchos pueblos de esta zircunferencia"

(from Caso Amador, p. 133, footnote 47)



Extract from geological map 877 (IGME). The quarry could have exploited one of several deposits: 81, yellow, limestone tufa; 20, orange hatched, limestone marble; 40, green limestone; 42: blue-green, arkose).

Sources

1566 List of ordinances MALDONADO FERNÁNDEZ, Manuel: http://manuelmaldonadofernandez3.blogspot.com.es/2010_04_01_archive.html [accessed October 25, 2012].

El Molar blog by MENA CABEZAS, Juan Eugenio : http://juaneugeniomena.blogspot.com.es/2010/12/etnologia-para-mejorar-la-oferta.html [accessed October 25, 2012].

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BA-3 Llera

Location and source: Llera is a small municipality (71 km2) in the south of the Province of Badajoz. The response to the Royal Census of 1791 records that in its surroundings there are quarries that are particularly apt for flour mills and quicklime (Caso Amador, 2008: 133, footnote 48). Unfortunately the precise location of these quarries is not known.

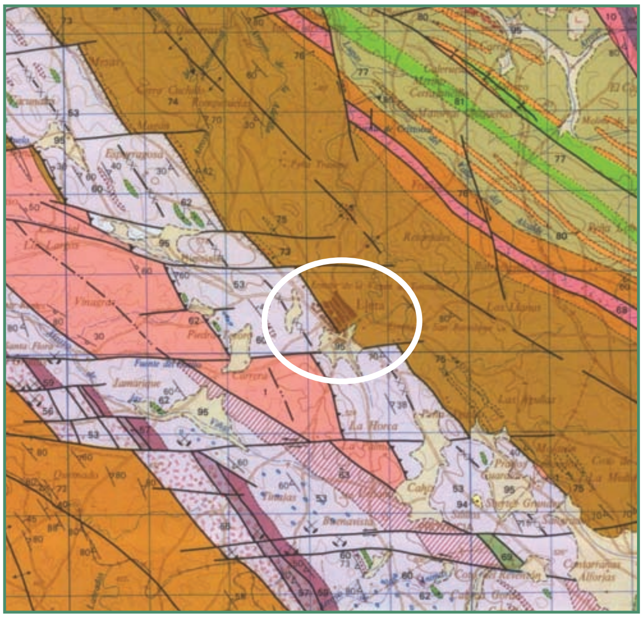
Dating: End of the 18th century.

Rock type: Although the millstone rock is not recorded, from the mention of quicklime in the response of the census, the most suitable material would be limestone. This rock, however, is not present on the geological map (Geological map 855, Usagre, 1980).

Extract from Responses to the Royal Census of 1791, Partida de Llerena, p. 605.

"No hay minerales de ninguna especie, solo hay algunas canteras o ***piedras proporcionadas para moler en los molinos arineros*** *y para hazer cal, de las que se haze uso quien las nezesita".*

(from Caso Amador 2008: 133, footnote 48).



Extract from geological map 855 (IGME) with the location of Llera. No outcrop on this map corresponds to the description given by the Responses to the Royal Census of 1791.

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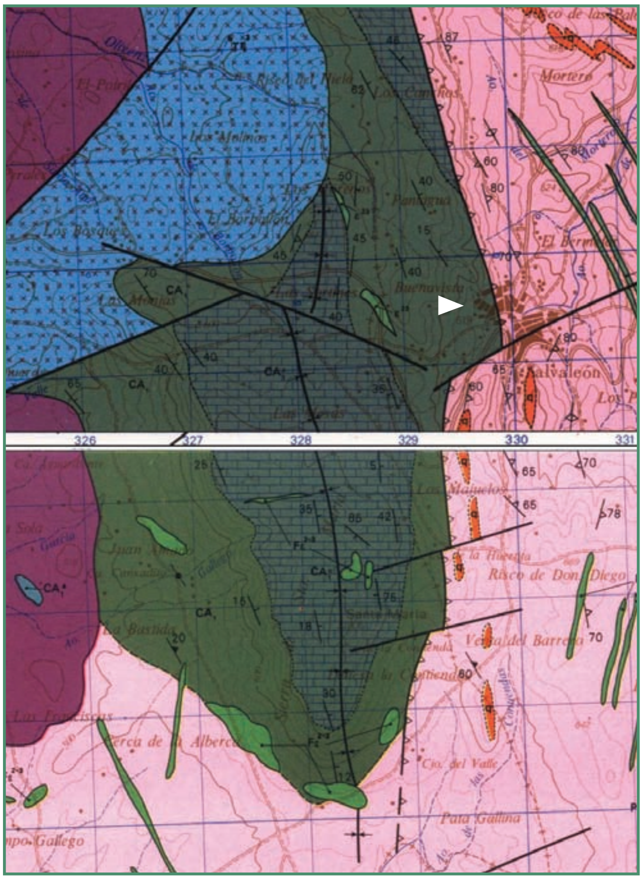
BA-4 Salvaleón

Location and sources: Salvaleón is a municipality covering a surface of about 70 km2 in the southwest of the Badajoz Province on the edge of the Sierra Morena. The first reference to millstone production comes from the early 19th-century *Diccionario Geográfico Universal,* in which "excellent" millstones are recorded (*DGU*, Vol. 8, 1833: 542). Madoz, a quarter century later, echoes the information and specifies that the quarry exploited a white stone for "*piedras de molino*" (Madoz 1949, Vol. 13: 711). The exact location of the quarry is unknown.

Dating: First half of the 19th century.

Rockype: The use of the word white suggests limestone. Outcrops of limestone are to the west of Salvaleón (Geological map 828, Barcarrota, 1975; Burguillos del Cerro 853, 1975).



Extracts from geological maps 828 and 853 (IGME). White limestones are in the dark green unit to the west of Salvaleón (CA1). The blue and pink units are granites.

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BA-5 Jerez de los Caballeros

Cerro de Berrocal
Dehesa Boyal

Location and source: Jerez de los Caballeros is a large municipality (740 km2) in the south of Badajoz. Madoz provides interesting details about the several millstone quarry sites. He states that there are quarries of both dark and white stone for bread mills (1847, Vol. 9: 627). Unfortunately he does not provide any other information about the sites.

A hiking itinerary posted on the internet mentions millstone workings at the Berrocal. The likely location of the sites is about 2 km south of the town at the Cerro del Berrocal and Dehesa Boyal, coinciding with a vast ourcrop of granite.

Dating: Middle of the 19th century.

Rock type: Granite (Geological map 875, Jerez de los Caballeros, 1981).

View from the northwest of the Cerro Berrocal (from Google maps Street View).

Extract from geological map 875 (IGME). The Dehesa Boyal and Berrocal place names are associated with the oval granite outcrop (pink) south of Jerez de los Caballeros.

Source

Forum of the Comarca de Jerez de los Caballeros: http://www.foros.net/search.php?mforum=jerezhabla [accessed July 3, 2012].

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MADOZ, Pascual. *Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar*, Madrid, Vol. 9,1847.

BA-6 Mérida district

Location and generalities: The Roman city of Mérida (*Augusta Emerita*) was founded in 25 BC along the Guadiana River. Most of its monumental structures were erected with granite coming from nearby quarries (Barrera 2000).

The Museo Nacional de Arte Romano conserves a large number of Roman rotary querns and ring-mills in its depository. From our observations, most of these stones were, like the monuments of the city, hewn from granite (Anderson *et al.* forthcoming). There are also what could be some small cylindrical watermills, possibly from Medieval times.

Although no millstone production site has been identified near Mérida, we suppose that the extensive granite fields north of the city supplied an important number of millstones .

View of the querns and millstones (and other artefacts) stored in the basement of the National Museum of Roman Art in Mérida. Most, from a typological standpoint, are Roman. Most are also of granite.

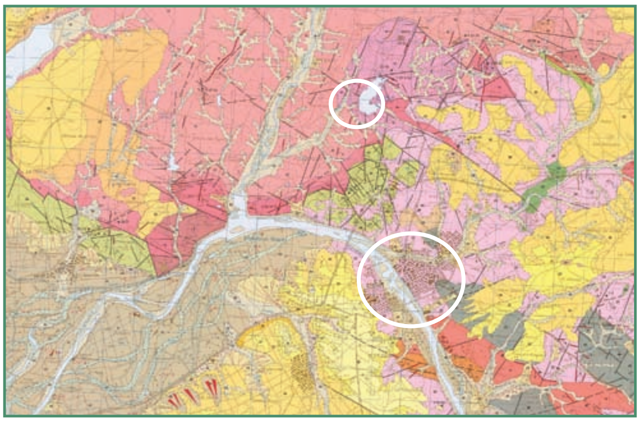
The most celebrated Roman granite quarry for construction material is at the Proserpina Dam, six km north of Mérida. This pit quarry was only discovered in 1990 when its waters were drained for restoration. The feature was studied before being once again filled with water (Barrera 2000: 193).

In the area of the dam, millstone makers would have had access to an unlimited amount of granite from either surface boulder or bedrock.

Dating: Roman and Medieval.

Rock type: Granite (Geological map 777, Mérida, 1990).

Detail of a granite Roman ring-mill.



Extract from geological map 777 (IGME). The area to the north of the city of Mérida is dominated by granitoid units (pink, red and light violet). The still active Roman dam of Proserpina, about 5 km from the city, was the site of a building block quarry. No quern or millstone quarry has been identified.

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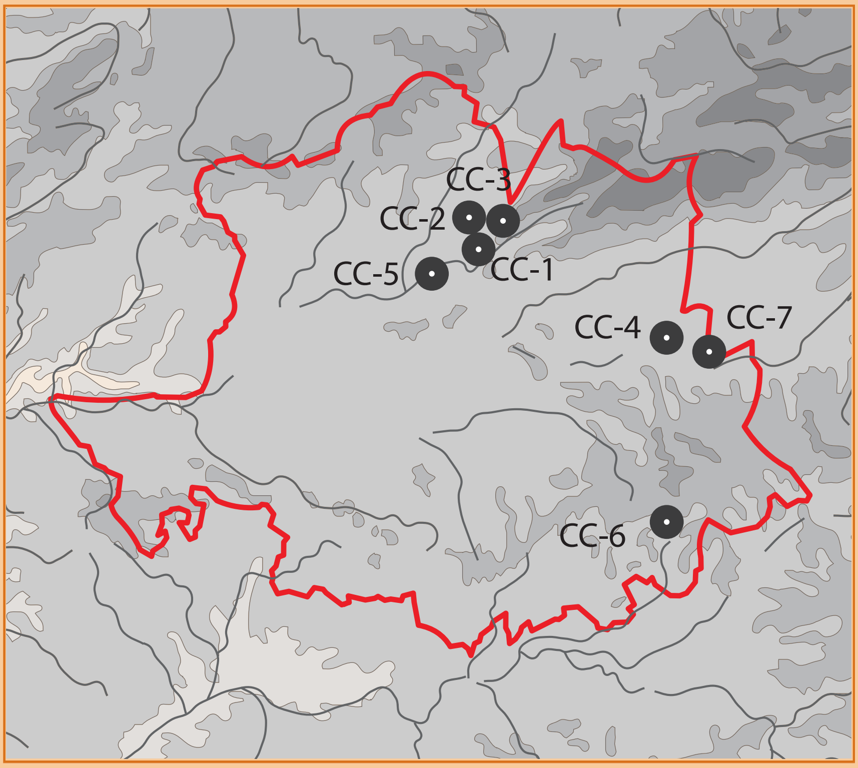
BARRERA, José Luis. *La Decoración Arquitectónica de los Foros de* Augusta Emerita, Roma, 2000, 487 p.

EXTREMADURA

CÁCERES (CC)



CC-1 Plasencia

Barrio del Pilar

Latitude: 40º 2' 13.09" N
Longitude: 6º 5' 22.99" W
Altitude: c. 400 m

Orthophoto of the millstone quarry of Plasencia in the park to the west of the municipal bullring (SIGPAC).

View of the millstone quarry from the northeast (photograph by M. Pulido).

Location: Plasencia is small city in the narrow Jerte River Valley between the Sierra of Berenguel and the Sierra Gorda. The millstone quarry, beside the municipal bullring, is one of Europe's rare urban exploitations and is now protected as a *BIC (Bien de Interés Cultural* - Heritage of Cultural Interest).

Source: The site is recorded in an internet blog by Montaña Domínguez. The author notes, based on the local Municipal Archives, that the millstone extraction originally stretched to the main road and possibly even to the river about one kilometre to the southwest.

The quarry: The site is a shallow surface quarry combining both contiguous and single extraction hollows.

Products and quantification: All of the extractions are large, with a diameter corresponding to that of hydraulic millstones. M. Domínguez informs me that she recalls about 100 extractions.

Transport and distribution: This quarry probably supplied the local watermills along the Jerte River. From the original extension of the site, it could have supplied mills beyond the local sphere.

Technique: Cylinders were scored by means of trenching, probably with picks. From the photographs it appears they were split by means of a single long channel cut along its base (instead of the regularly spaced wedge holes). This would need to be confirmed.

Dating: The extraction hollows correspond to millstones about 1,00 m in diameter. This size suggests a date spanning from the Medieval to Contemporary times.

Rock type: Granite (Geological map, 598, Plasencia, 1984).

Examples of shallow extraction hollows (photograph by M. Pulido)

View of a sector of the quarry with the Municipal bullring in the background (photograph by M. Domínguez).

Base of an extraction hollow. The cylinder was split from the bedrock by means of wedges set in what appears to be a continuous channel cut along its base (photograph by M. Domínguez).

Abandoned cylinder (photograph by M. Domínguez).

View of an extraction hollow. The parallel lines suggest the trench was cut with a pick (photograph by M. Pulido).


Examples of extraction hollows cut into outcrops of bedrock (photographs by M. Domínguez).

Extract from geological map 598 (IGME). The quarry is in a granite unit (orange).

Source

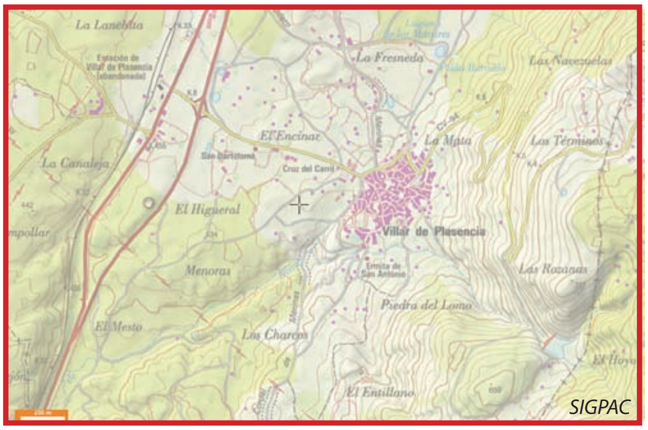
Montaña DOMÍNGUEZ CARRRO: http://blogs.hoy.es/geografiainterior/2012/10/01/una-cantera-unica-en-espana-en-pleno-barrio-del-pilar [accessed 25 December, 2012].

Acknowledgements

I kindly thank Montaña DOMÍNGUEZ and Mara PULIDO for their photographs.

CC-2 Villar de Plasencia 1

Latitude: N
Longitude: W
Altitude: m



SIGPAC

Location and source: Villar de Plasencia is 13 km north of Plasencia along the edge of the Llanos de Jarrilla Plain at the foot of the Montes Tras la Sierra. Miñano records that millstones were extracted from the many surface rocks "... and transported up to 4 and 6 leagues away" (Miñano 1828, Vol. 9: 433). The author, however, provides no clue as to the location of the quarry.

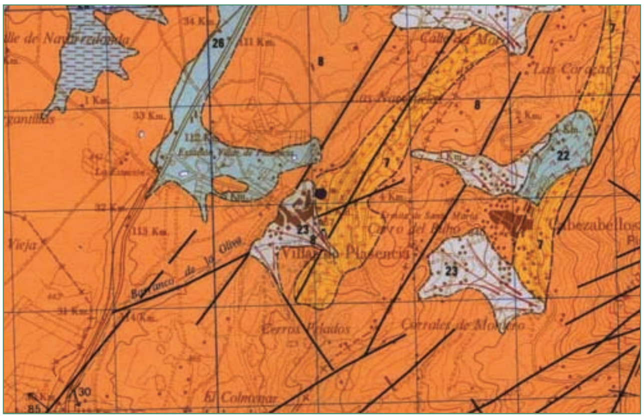
Product and quantification: Although Miñano does not specify the product, we assume that the stones were destined for the watermills along the nearby streams that run down the mountain.

The quarry: The town is in the heart of a vast granite district. We therefore assume that the millstones were scored from either surface blocks or shallow surface quarries.

Transport and distribution: The town is on the Via de la Plata (Silver Way), an ancient N-S thoroughfare. The statement by Miñano detailing the distances of 4 to 6 leagues, roughly 20 to 30 km, indicates that these quarries supplied millstones slightly beyond the local sphere.

Dating: First half of the 19th century.

Rock type: Granite (Geological map, Plasencia 598, 1984).



Extract from geological map 598 (IGME). The surroundings of Villars de Plasencia are dominated by granites (oranges). The grey units are recent alluvial deposits unfit for millstone production.

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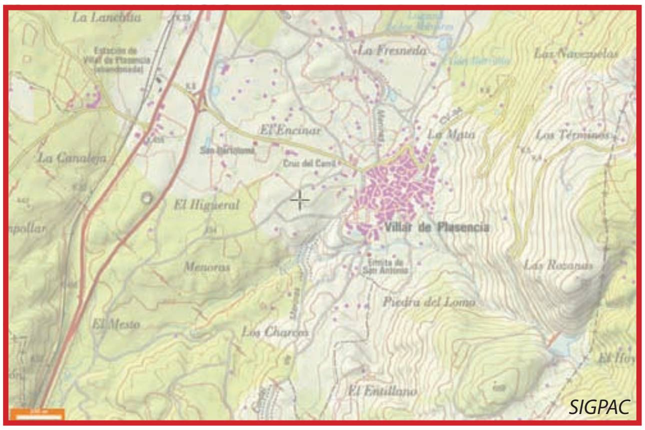
MIÑANO y BEDOYA, Sebastián. *Diccionario Geográfico y Estadístico de España y Port*ugal, Vol. 9. 1828, Madrid.

CC-3 Villar de Plasencia 2



View of circular carving in the surroundings of Vilar de Plasencia. The beginning of a trench is seen on the right of the image (photograph by Inma Estévez).

Location and source: These small circular extractions are identified in an archaeological forum on the internet (see source). According to the author, the interconnected holes are receptacles for water. Although the extractions certainly served as receptacles, we propose the cuttings were intended for rotary querns. This is yet to be confirmed.

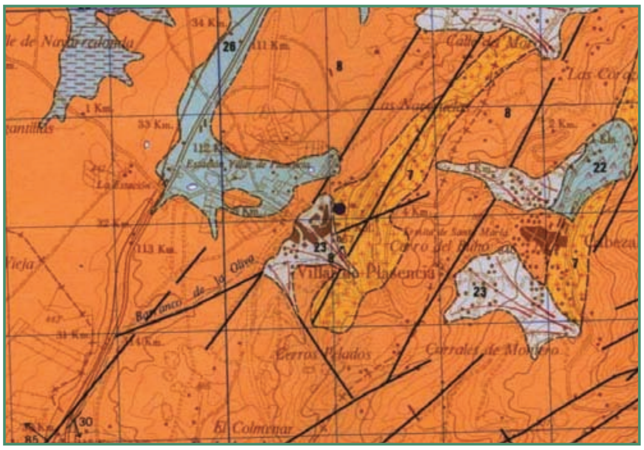
The quarry: Cylinders appear to have been scored directly from the rock by means of narrow circular trenches. An unfinished trench is visible to the right on the first photograph. One of the better preserved hollows shows at its base, along the circumference, a series of what appears to be wedge holes or other types of cavities for splitting.

Product, quantification and distribution: The extractions are relatively small, about 40 cm, corresponding to rotary querns. Although the number of extractions is not indicated, from the pictures, we have the impression of a very modest, local exploitation.

Dating: The size and relative thickness of the cylinders suggest a pre-Medieval date, possibly Roman (or even Iron Age).

Rock type: Granite (Geological map, Plasencia 598, 1984).

Detail of a circular carving. Along the circumference are what appear to be chisel or wedge holes (invaded by moss) to split the cylinder (photograph by Aníbal Clemente).



Extract from geological map 598 (IGME). The surroundings of Villars de Plasencia are dominated by granites (oranges). The grey units are recent alluvial deposits (certainly unfit for millstone production).

Source

Forum Arqueólogos: http://www.historiayarqueologia.com/photo/cazoletas-en-villar-de-7 [accessed February 11, 2013].

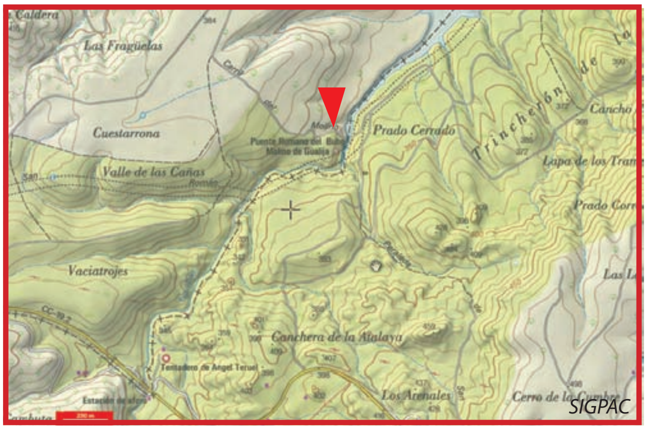
Acknowledgements

I warmly thank AníbalCLEMENTE for use of the photographs.

CC-4 Bohonal de Ibor

Molino Gualija

Latitude: 39º 46′ 21.10″ N
Longitude: 5º 24′ 29.34″ W
Altitude: c. 320 m



Location and sources: In his description of Bohonal de Ibor, Madoz records that "... there are many *berrocales* (granites) and quarries of a very hard rock where very good millstones are extracted" (Madoz 1846, Vol. 4: 376).

The site of Molino Gualija, identified in a blog by J. Pérez Ross, coincides perfectly with this description. The quarry is beside the ruins of the Gualija Molino, at a bend of the River Gualija about 6 km southeast of Bohonal de Ibor. It is beside an ancient thoroughfare marked by a Medieval stone bridge.

The quarry: The site consists of a small series of extraction hollows carved directly into small granite surface outcrops.

Products, quantification and distribution: The few millstone extractions correspond, most likely, to the demands of the adjacent Molino Gualija. Stones of this type, according to J. Pérez Ross, are still visible in the mill. If the quarry ever supplied millstones farther away, the nearby road will have facilitated transport.

Toponymy: The eastern bank of the Gualija River in the Municipality of Paraleda de San Román, corresponds, according to the cadastre, to the place name *Los Berrocales*, a term designating granite outcrops and at times associated with millstone quarries.

It cannot be excluded that many of the millstone exploitations alluded to by Madoz are now under the waters of the large Valdecañas dam in the northern area of the municipality.

Dating: First half of the 19th century.

Rock type: Granite (Geological map, 653, Valdeverdeja, 1978).

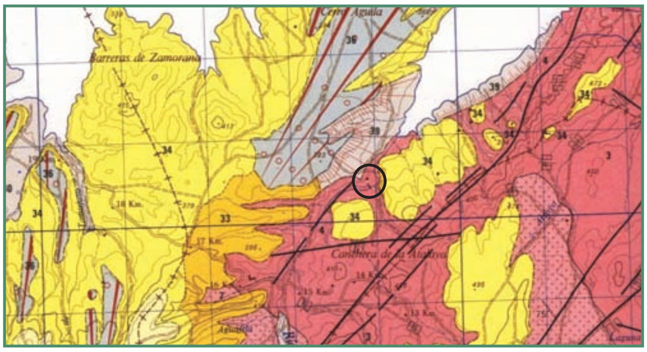
*Aerial view of the Gualija Molino quarry area with the many granite (*berrocal*) outcrops especially, along the Gualija River bank (SIGPAC). The quarry is between the old mill and the bridge.*

View from the north of the abandoned Gualija watermill (photograph by Javier Pérez Ross).

Detail of an extraction hollow. The old bridge is seen in the background. Circular tool marks suggest the use of the pick to cut the trench around the cylinder (photograph by Javier Pérez Ross).

Detail of an extraction hollow (photograph by Javier Pérez Ross).

Detail of two extraction hollows (photograph by Javier Pérez Ross).



Extract from geological map 653 (IGME). The rock is a coarse grained granite (pink, unit 4). The yellow unit (34) is a combination of conglomerate and arkose, rocks that are also known to have been exploited for millstones.

Source

Javier PÉREZ ROSS "Cosas de un Extremeño: http://extremadurense.blogspot.com.es/2012/06/molino-gualija-peraleda-de-san-roman.html [accessed February 15, 2013].

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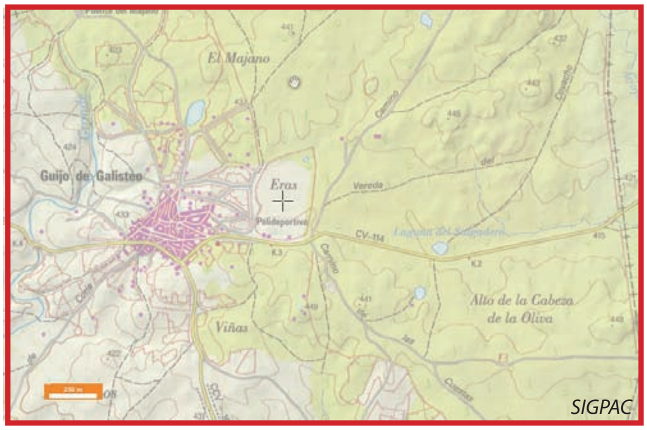
Acknowledgements

I thank Javier PÉREZ ROSS for the information and photographs of the site.

CC-5 Guijo de Galisteo

Dehesa Boyal

Latitude: c. 40º 5’52.16”N
Longitude: c. 6º 23’31.46 W
Altitude: c. 420-440 m



Location: The millstone quarry is in the flat Dehesa Boyal east of Guijo de Galisteo.

Source: The quarry is identified by Elema Garrido and Miguel Ángel in a website relating to the places of interest around the town of Guijo de Galisteo.

The quarry: The exploitation is an extensive, shallow surface quarry with cylinders cut along horizontal planes. The hollows are either isolated or in small groups.

Product: According to the authors of the website, the quarry comprises between 20 and 30 large extractions about a metre in diameter (for watermills). There is no indication of any other types of products.

Distribution: This small quarry supplied the local mills.

Dating: This site could date from Medieval to Contemporary times.

Rock type: Two-mica porphyric granite (Geological map, Montehermoso, 597, 1984).

Views of abandoned millstones at the quarry of Guijo de Galisteo (all photographs by Miguel Ángel López).

Views of extraction hollows at the quarry of Guijo de Galisteo (all photographs by Miguel Ángel López).

Extract from geological map 597 (IGME). The orange unit is granite (2 micas).

Source

Internet photographs: http://www.pueblos-espana.org/extremadura/caceres/guijo+de+galisteo/galeria-fotografica/ [accessed February 13, 2012].

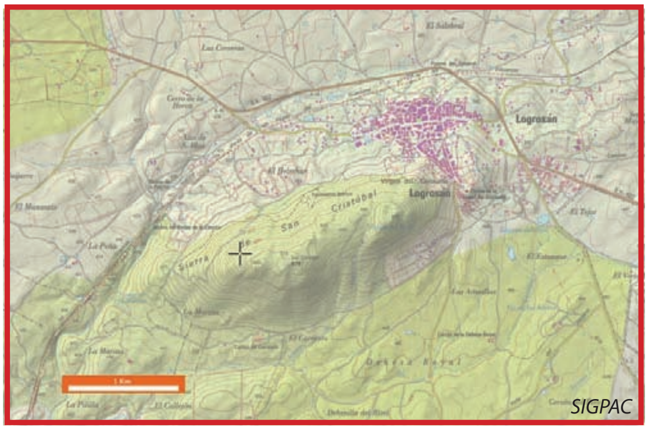
Acknowledgements

I warmly thank Cándido RODRÍGUEZ HERNÁNDEZ, Elena GARRIDO and Miguel Ángel LÓPEZ for the information and the photographs.

CC-6 Logrosán

Sierra de San Cristóbal

Latitude: 39º 19′ 32.29″ N
Longitude: 5º 30′ 23.49″ W
Altitude: c. 660-670 m



Location: The town of Logrosán is at the foot of the *Sierra de San Cristóbal*, a mountain with a history of exploiting tin dating from the Bronze Age until the 1950s.

Sources: Madoz records that many millstones, wine presses and construction blocks were scored from a "*piedra de grano*" (coarse grained rock) on this mountain (Madoz 1847, Vol. 10: 355).

Merideth, in the synopsis of his doctoral thesis about protohistoric tin exploitation, specifies that "...*within this central summit area on the upper south side is a granite area which has been used to quarry millstones, a couple of which are partially cut out and still remain in their original settings*". Although the author does not specify the sizes of the extractions, he notes that they were probably Medieval or later (Merideth 1998: 67).

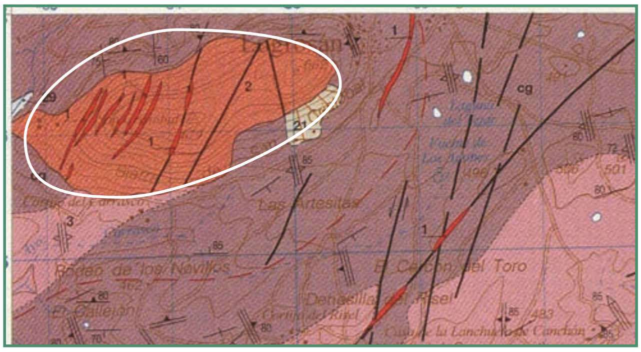
Transport and distribution: A road or path that zigzags down the northern slope of the mountain from the quarry is clearly visible on the aerial photograph.

View from the northwest of the southern summit of the Sierra of San Cristóbal Mountain (extract from Google Maps Street View).

This road would have been the most simple course to transport the cumbersome millstones from the mountaintop to the town of Logrosán.

Dating: 19th century.

Rock Type: Coarse grained two-mica granite (Geological map 732, Valdecaballeros, 1995). This definition coincides perfectly with that of Madoz in 1847).



The quarry is in a unit of coarse-grained, two-mica granite (orange). The red strips are veins of quartz.

Source

Geological website by Juan GIL MONTES: http://jugimo.blogspot.com.es/2010/12/las-villuercas-lugares-de-especial.html [accessed October 25, 2012].

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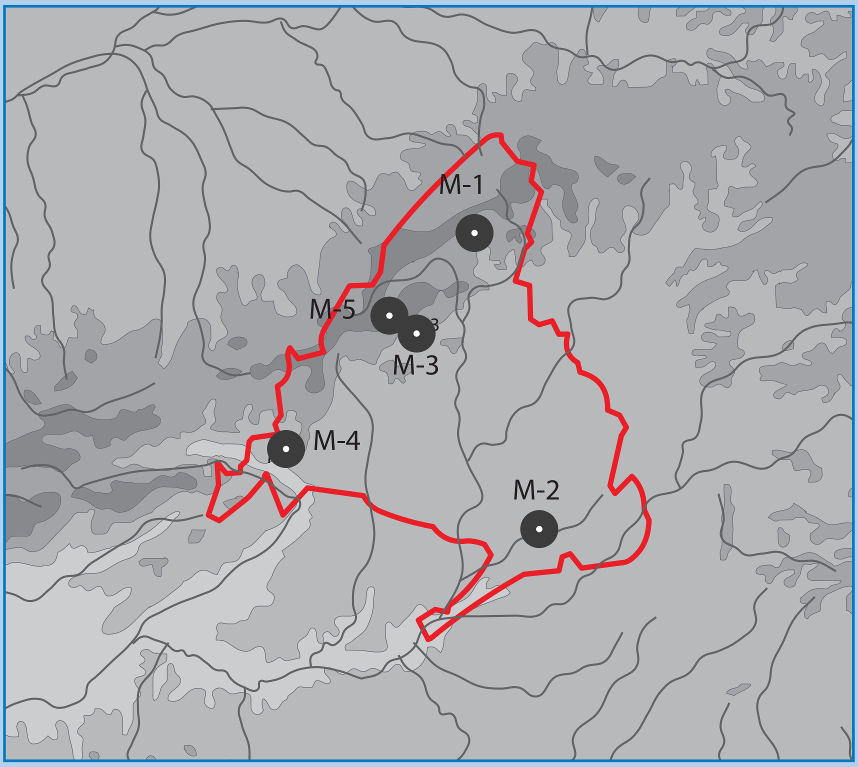
MADRID
MADRID (M)



M-1 El Berrueco

Location and generalities: El Berrueco is a small town in the north of the Community of Madrid at the foot of the Guadarrama mountains. Since 2001, the town honours its long tradition of stone working with a display in its streets of products from its old quarries (basins, feeding troughs, jambs and lintels, threshing rollers, millstones).

Source: Information about this site is from a geological itinerary through the north of the Community of Madrid (Días Martínez & Rodríguez Aranda 2006: 53-55).

Toponymy: The name *Berruecos* (Pre-Roman, possibly of pre-Indo-European origin) is synonymous with granite (Llorente Pinto 2011: 75). It evokes crags and landscapes of rounded granite boulders sculpted by nature.

The quarry and techniques: There is no specific information about the millstone production. The half-carved cylinder exhibited in town appears to be fashioned from a previously detached angular block. Granite outcrops and surface boulders abound in the area. It is therefore possible to imagine a variety of quarry types, from surface boulder, to block detachment or true extractive workings.

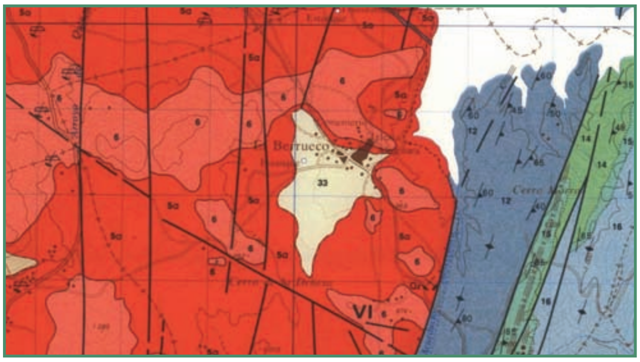
Products, quantification and distribution: Only one millstone (exhibited) is certified. We suppose, owing to the accessibility of the rock, that many more were produced in the municipality. They probably supplied the watermills along the local streams and river.

Dating: From the diameter of the roughout, production took place any time between Medieval or Contemporary times.

Rock type: Granite (Geological map 484, Buitrago del Lozoya, 1988). The geological itinerary notes two units of granite in the surroundings of El Berrueco. The first (leucogranite) is reddish, with a fine texture, and is more resistant to weathering. The second (monzonite) is a darker red colour with coarser grains, and is more subject to weathering. It is the second, according to the geologists, that was more often in the form of naturally rounded surface boulders (Días Martínez & Rodríguez Aranda 2006: 53-55).

An unfinished millstone exhibited at the open air museum of the town of Berruecos (photograph by Gloria Gómez Trapero from http://prejubiladasinfronteras-glo.blogspot.com.es/2012/10/el-berrueco-madrid.html).

An example of the granitic landscape on the western outskirts of El Berrueco (extract from Google Maps Street View).



Extract from geological map 484 (IGME). The reddish zones are granite units. The cream-coloured unit immediately surrounding the town corresponds to alluvial deposits.

Sources

Website Gloria GÓMEZ TRAPERO, http://prejubiladasinfronteras-glo.blogspot.com.es/2012/10/el-berrueco-madrid.html).[accessed December 7, 2013].

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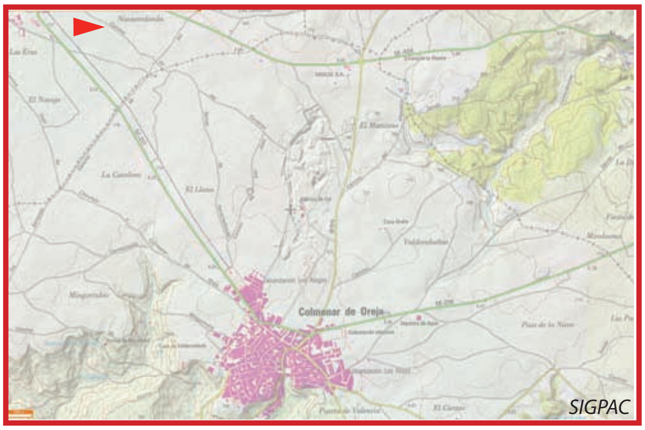
Acknowledgements

I thank José Manuel DELGADO of the Municipality of El Berruecos for oral information about the site.

M-2 Colmenar de Oreja

Las Canteras

Latitude: c. 40º 7′ 26.75″ N
Longitude: c. 3º 22′ 59.53″ W
Altitude: c. 770 m



View from the west of the quarries of Colmenar de Oreja (from Google Maps Street View).

Orthophoto of the Colmenar de Oreja quarries (SIGPAC). The extractions today, to the south, are destined to the plaster industry.

Location and generalities: Colmenar de Oreja is in the Madrid Basin in the southeast of the Community. It prides itself on its large *tinajas* (clay vessels) and "*piedra de Colmenar*" (Colmenar stone).ç

In the middle of the 16th century, the quarries were acquired by King Philip II for the building of the Royal Palace of Aranjuez, 16 km away (Website of the Community of Madrid). Other illustrious buildings in Madrid were also erected with this stone. Today the site is a vast exploitation dedicated to the quicklime industry.

Sources: In 1788, the responses of a local cleric to the Survey of Tomás López recorded that "white stone" quarries in the plain to the north of Colmenar de Oreja yielded material for buildings in Madrid and Aranjuez. The source specified that many "factories" of this white stone made millstones for "*atahonas arineras*" (animal-driven flour mills) (Puche & Mazadiego 1999: 93).

A second reference to millstones is in a treatise about hydraulic power (1833) describing the dressing of millstones from Colmenar (see below) (Vallejo 1833: 387).

Two decades years later Madoz recorded that these white quarries were in decline except for the production of baths and millstones for *tahonas* in Madrid (Madoz 1847, Vol. 6: 525).

About 50 years later an anonymous report in the *Revista de Obras Públicas (ROP,* 1896) places the millstone workings to the north of the city and offers very detailed information about the different rock layers (see below).

Toponymy: The *Canteras* (quarries) place name appears to the north of Colmenar on the geological map. Although the name no longer appears on the geographical map (*SIGPAC*), it is plausible that a road in the area (*Camino de las Canteras*) alludes to the old production.

The quarries: From the *ROP* report we gather that the first two layers of rock (respectively 28 to 84 cm and 28 to 36 cm thick) are not necessarily exploited due to their mediocre quality. The third layer, called the *sobrebanco* (upper layer), is 56 to 84 cm thick and was used for building stones and millstones (*Revista de Obras Públicas* 1896: 145).

Extraction at the site was known to have taken place underground. From this detailed description of the layers (*ROP*1896), we can assume that the millstone workings were shallow and must have been in the open air. We ignore, however, if extraction consisted of detaching angular blocks or scoring directly from bedrock.

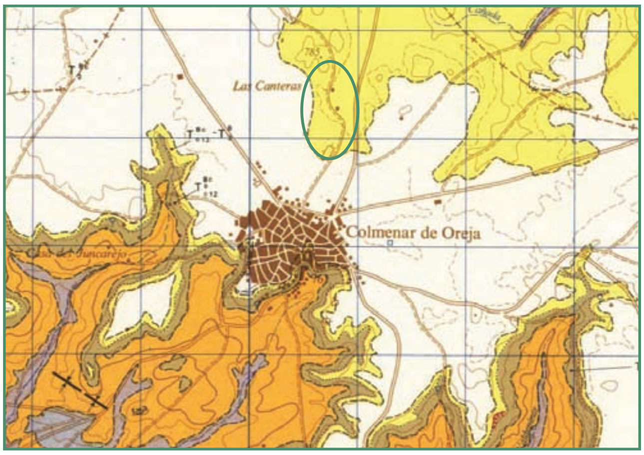
Products and quantification: Vallejo records that Colmenar millstones measure one *vara* (between 76,8 and 91,2 cm) and can grind for 6 straight hours before they have to "rest and be dressed" (Vallejo 1833: 387). The author explains that in 24 hours they usually worked for two six-hour stretches, but could, in certain occasions, run up to three six-hour stretches because dressing required two hours (Vallejo 1833: 387).

Transport and distribution: These quarries certainly supplied millstones to the surrounding areas. For more long-distance export, the production would have benefitted from the network of transport of the construction material to Madrid. The *Camino de las Canteras* road leads from quarries to the town of Chinchón to the northwest. From Chinchón there were no major geographical obstacles to attain Madrid, about 50 km northwest.

Dating: Building block workings are recorded since the 16th century. Millstone work, however, is only certified by written sources since the late 18th century to the end of the 19th century. It is of note that the stones of a watermill restored in 1587 in Aldehuela, 10 km to the south of Colmenar, were not supplied by Colmenar, but imported from Ventas con Peña Aguilera (TO-2), a granite quarry about 100 km to the southwest (Baltanás 1998: 36-37). This suggests that the early Colmenar workings of the 16th century were dedicated primarily to construction material.

Rock type: White limestone (Geological map 606, Chinchón, 1977).

*Millstones in the Malasaña neighbourhood of Madrid reputed to be "*tahona*" millstones (animal-driven flour mill) from Colmenar Oreja (photograph by Carlos Osorio, Caminando por Madrid: http://caminandopormadrid.blogspot.com.es/2012/02/dos-ruedas-de-molino-en-una-corrala-de.html).*



Extract from geological map 606 (IGME). Although the yellow unit is a combination of limestones, sandstones and conglomerates, the rock exploited in the quarries is unquestionably a white limestone.

Sources

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Carlos Osorio blog Caminando por Madrid: http://caminandopormadrid.blogspot.com.es/2012/02/dos-ruedas-de-molino-en-una-corrala-de.html [accessed October 26, 2012].

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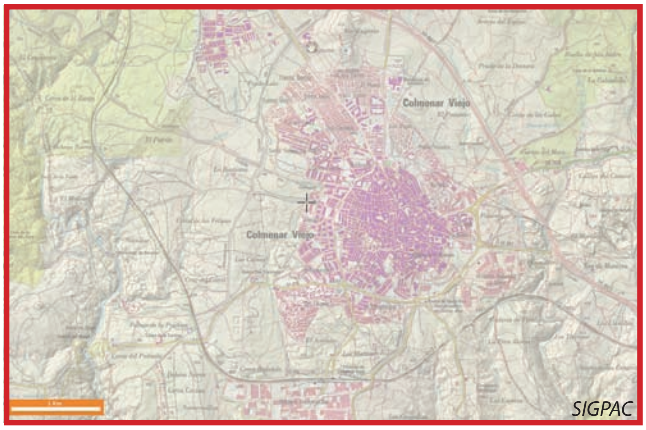
Acknowledgments

I thank Carlos OSORIO for the photographs of the millstones from Madrid.

M-3 Colmenar Viejo



Location and generalities: Colmenar Viejo (not to be confused with that of Colmenar Oreja, M-2) is 20 km north of Madrid in the Manzanares Basin at the foot of the Sierra de Guadarrama. It has a long tradition of working granite both for construction (building blocks and cobblestones) and millstones. It is worth noting that Colmenar Viejo is but among a number of towns (e.g. Alpedrete, Zarzalejo, Moralzarzal and Cadalso de los Vidrios,) where granite was exploited on a large scale.

Sources: A number of *berroqueño* (granite) millstone workings are recorded in the Survey of King Philip II (1574-1578) (García Valcárel *et al*. 1998: 49). Madoz, three centuries later, also referred to granite millstones quarries for flour mills (Madoz 1847, Vol. 6: 530). A second geographical dictionary two years later echoes the notions of Madoz (Fernández de los Ríos 1849: 118).

A series of postcards from the beginning of the 20th century (two are represented here) document of the stages of granite production. These documents, however, illustrate only block and cobblestone production.

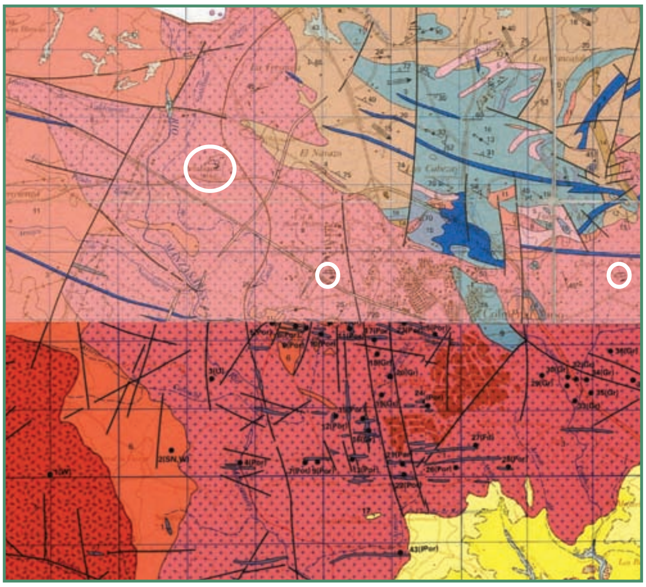
The quarries: Granite in this region was exploited, as seen in the old postcards, in the form of surface blocks and shallow outcrops or in deep pit quarries.

Dating: Millstone production is recorded at the end of the 16th century and in the 19th century. It is reasonable to assume it continued uninterrupted between these dates.

Old postcard with an example of a surface block quarry scene from the surroundings of Colmenar Viejo (from Todo Colección website).

Old postcard illustrating a deep pit quarry in Colmenar Viejo (from Tesoros de Ayer website). The product of this quarry was probably building material.

Rock type: Granite (Geological map 534, Colmenar Viejo, IGME, 993 and Geological map Torrelaguna, IGME, 509, 1986-87). According to the website recording the historical quarries in the Community of Madrid (Canteras Históricas de la Comunidad de Madrid), the granite extracted in Colmenar Viejo is grey with regular-shaped grains measuring between 1 and 5 mm.



Montage of geological maps 534 and 509 (IGME). Granite units (reddish hews) dominate the surroundings of Colmenar Viejo. The circles indicate the abandoned quarries. Millstone production, however, is not identified in the field.

Sources

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M-4 Chapinería

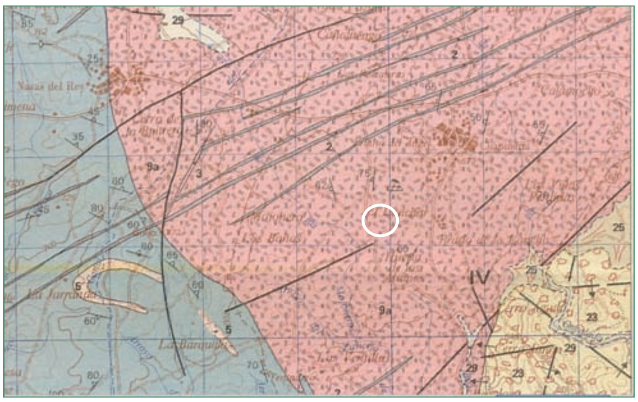
Location and source: Chapinería is a small municipality in the west of Madrid at the foot of the Sierra de Guadarrama Mountains. The town is surrounded by a *berroqueño* (granite) landscape. Quarries for building material and millstones are mentioned by Miñano (1826, Vol. 3: 83). The author provided no information as to their location.

The quarry and toponymy: From the orthophotos *(SIGPAC)* and the geological map (IGME 557) there is a large abandoned granite exploitation at the place name *El Lanchar* (meaning quarries where slabs are extracted) on the southwestern outskirts of the town. This site could have yielded millstones. Another option is that they were scored from *piedras caballeras* and *bolos* (naturally detached and rounded surface blocks), a common geological feature in the area.

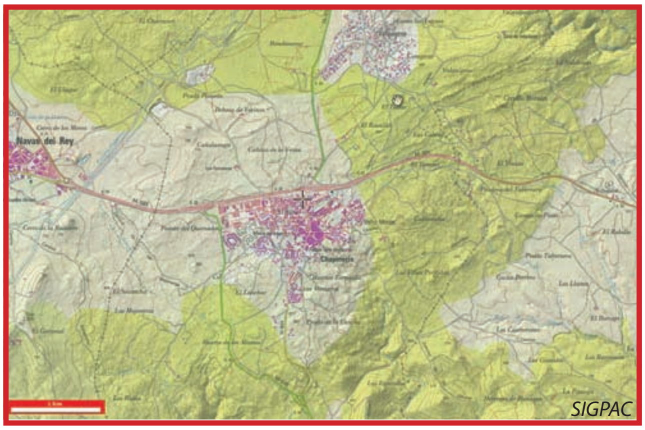
Product and distribution: Millstones for watermills. There is no evidence of distribution beyond a local sphere.

Dating: First half of the 19th century.

Rock type: Granite (Geological map 557, Valdeiglesias, 1988).



Extract from geological map 557 (IGME). Both the pink (granite) and the yellow (granite and gneiss surface boulders) units are potential millstone sources. The circle indicates the Lanchar *exploitation.*



Orthophoto of the granite exploitation at El Lanchar, to the southwest of the town (SIGPAC).

View from the west of the granite exploitation at El Lanchar (Google Maps Street View).

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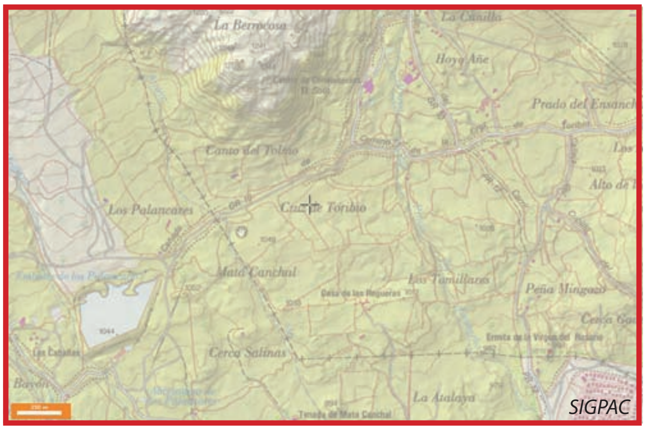
M-5 Miraflores de la Sierra

Cerca de la Rama

Latitude: 40º 46’ 39.74” N
Longitude: 3º 48’ 32.74” W
Altitude: c. 1030 m



Views of a partially cut trench around a cylinder (photograph by F. Colmenarviejo).

Unfinished millstone (photograph by F. Colmenarviejo).

Location: The quarry of *Cerca de la Rama* is on a hillock near the Escaramujal stream at the border between the Municipalities of Miraflores de la Sierra and Soto del Real along the southern border of the Guadarrama Mountains.

Source: The site was brought to my attention by the archaeologist Fernando Colmenarviejo during my inquiries about millstone production around the town of Colmenar Viejo (M-3).

Toponymy: In the surroundings of the town there are several place names that are evocative of both granite and surface outcrops: *Berrocoso* (granitic), *Tolmo* (surface boulder) and *Canchal* (rock, crag).

The quarry: The site comprises abandoned millstones in different stages of production. Some are still in connection with the rock and others are in the process of fashioning.

Techniques: From the photographs we can determine both true extractive trenching techniques as well as detaching blocks with levers.

Products and distribution: The millstones range in diameter from 1,25 to 1,40 m and are between 27 and 34 cm thick. Production is modest, on a local level.

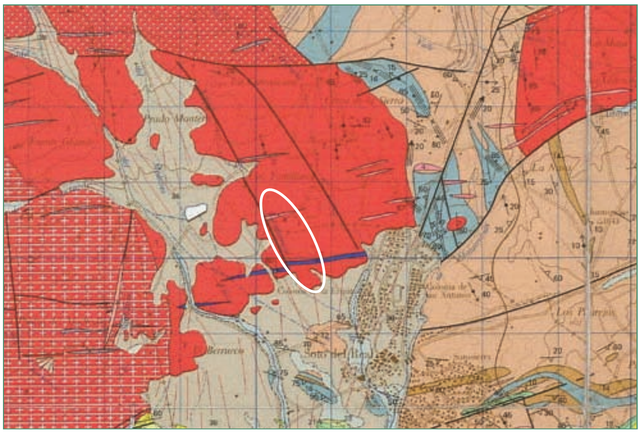
Dating: The size of the millstones suggests a production that could date in the time frame between the Medieval and Contemporary periods.

Rock type: Granite (Geological map 509, Torrelaguna, 1987).

Angular extraction hollow where a square block was presumably extracted to be fashioned into a millstone (photograph by F. Colmenarviejo).

Abandoned millstone in an advanced state of fashioning (eye at least partially pierced) (photograph by F. Colmenarviejo).

Examples of scoring directly into the granite layer (photograph by F. Colmenarviejo).



Extract from geological map 509 (IGME). The site coincides with the red granite unit.

Acknowledgements

I thank archaeologist Fernando COLMENARVIEJO, of Colmenar Viejo, for the photographs and information about the millstone production.

UNIVERSITÉ DE GRENOBLE

THÈSE

Pour obtenir le grade de

DOCTEUR DE L'UNIVERSITÉ DE GRENOBLE

Spécialité: Histoire

Présentée par

Timothy J. ANDERSON

Thèse dirigée par Alain BELMONT

préparé au sein du LARHRA (CNRS UMR 5190)
dans l'École Doctorale Sciences de l'homme,
du Politique et du Territoire

Les carrières de meules du sud de la péninsule Ibérique, de la protohistoire à l'époque moderne

PART III

RÉSUMÉ EN FRANÇAIS

RÉSUMÉ EN FRANÇAIS

Les carrières de meules du sud de la péninsule Ibérique, de la protohistoire à l'époque moderne

Ce résumé comprend la traduction de l'anglais vers le français de l'avant propos et les chapitres 1, 2 et 13 du texte. L'avant-propos, ainsi que les chapitres 1 (introduction) et 2 (sources, ressources et travaux de terrain) établissent les circonstances et la base de l'étude, alors que la conclusion (chapitre 13) résume les principaux points développés tout au long du travail. Les illustrations les plus pertinentes sont présentées avec leur numéro de figure d'origine de manière à faciliter la consultation de la version originale anglaise.

Avant-propos

Comme archéologue habitué à travailler dans des secteurs bien définis d'une fouille, la tâche d'affronter le sujet des anciennes carrières de meules dans une si vaste zone géographique, de Madrid à Málaga et Huelva à Valence (environ 300.000 km2), et couvrant un période de temps de plus de 2500 ans, était particulièrement redoutable. Il s'agit d'une échelle beaucoup plus vaste que celle que j'ai étudié il y a une douzaine d'années lors de l'étude de la carrière de meules de Châbles dans le Canton de Suisse (Anderson *et al*. 2003).

En raison de l'ampleur de l'entreprise, j'ai été rapidement confronté à une série d'obstacles qui rendaient une étude quantitative, mon objectif initial, impossible. Rien n'aurait pu me satisfaire plus que de passer des journées sur chaque meulière, afin d'en réaliser un arpentage précis des caractéristiques topographiques, d'en mesurer chaque alvéole d'extraction et chaque ébauche de meule ou meule accidentée. En outre, il aurait été extrêmement enrichissant de mener à bien une série de diagnostics archéologiques suivant les principes actuels de la stratigraphie, afin d'acquérir des données chronologiques sur chaque site, observer et documenter les marques d'outils dans des conditions optimales dans l'objectif de déterminer les anciennes techniques d'extraction et les outils employés. Enfin, il aurait été souhaitable de recueillir systématiquement des échantillons de roches pour des analyses pétrographiques. A part ce travail de terrain, il aurait été profitable d'interroger des historiens locaux, ainsi que de dépouiller les archives historiques pour identifier des anciens protocoles notariaux ou ordonnances municipales qui auraient pu fournir des informations précieuses à propos de l'histoire d'une meulière et de ces meuliers.

Au lieu de cela, en raison du manque de financement, la plupart de mon temps de recherche a été passé derrière l'écran d'un ordinateur, sur internet ou dans les bibliothèques, passant au crible les anciens textes géographiques et géologiques, des cartes, des cadastres et bien entendu la littérature molinologique spécialisée, en essayant de identifier même l'indication la plus éloignée d'une ancienne meulière.

Je n'ai pas eu l'occasion de visiter tous les sites présentés dans ce travail et j'ai souvent dû m'appuyer sur des informations et des documents secondaires, notamment des photographies. Même si cela a été d'une grande aide pour identifier les sites, il n'était pas possible de s'appuyer sur des informations plus détaillées d'un œil non averti car il pourraient avoir ses effets négatifs sur la quantification de la production, l'interprétation des traces d'outils, et la détermination de la pétrographie.

En outre, lorsque sur le terrain, la difficulté de repérer certains sites, qui s'apparentait souvent à la recherche d' une aiguille dans une botte de foin, a été porté souvent par la présence d'obstacles (clôture ou les animaux agressifs) qui m'a empêché culminer la quête.

Ce travail doit donc être considérée d'avantage comme qualitatif que quantitatif, une première incursion ou bilan dans un domaine complètement inexploré, avec le but d'identifier le plus grand nombre de sites possible pour analyser leur production et leur pétrographie, et de tenter, à partir d'un point de vue diachronique, de déterminer les tendances dans les types de produits de broyage, les techniques de production et de logistique, la propriété du site et son personnel, le choix des matières premières et la distribution commerciale.

15.1: Introduction

15.1.1. Des meulières partout

Avant le réseau commercial actuel produisant un pain éloigné de son lieu de consommation, le blé et les autres céréales ont été moulus et cuits sur place. Tout au long de l'histoire, après les phases de récolte et de stockage, les grains devaient être moulus pour leur consommation, une activité qui a eu lieu dans des différents types de moulins actionnées par l'homme, ou encore par l'animal, l'eau ou le vent. Chacune de ces moulins était équipé d'au moins deux pierres. Des témoins de meules dès les premiers jours de la révolution agricole du néolithique à l'histoire très récente sont répandus dans le sud de l'Espagne, comme on le voit à travers les pièces récoltes lors des fouilles archéologiques ou de grandes meules décorant des espaces publics.

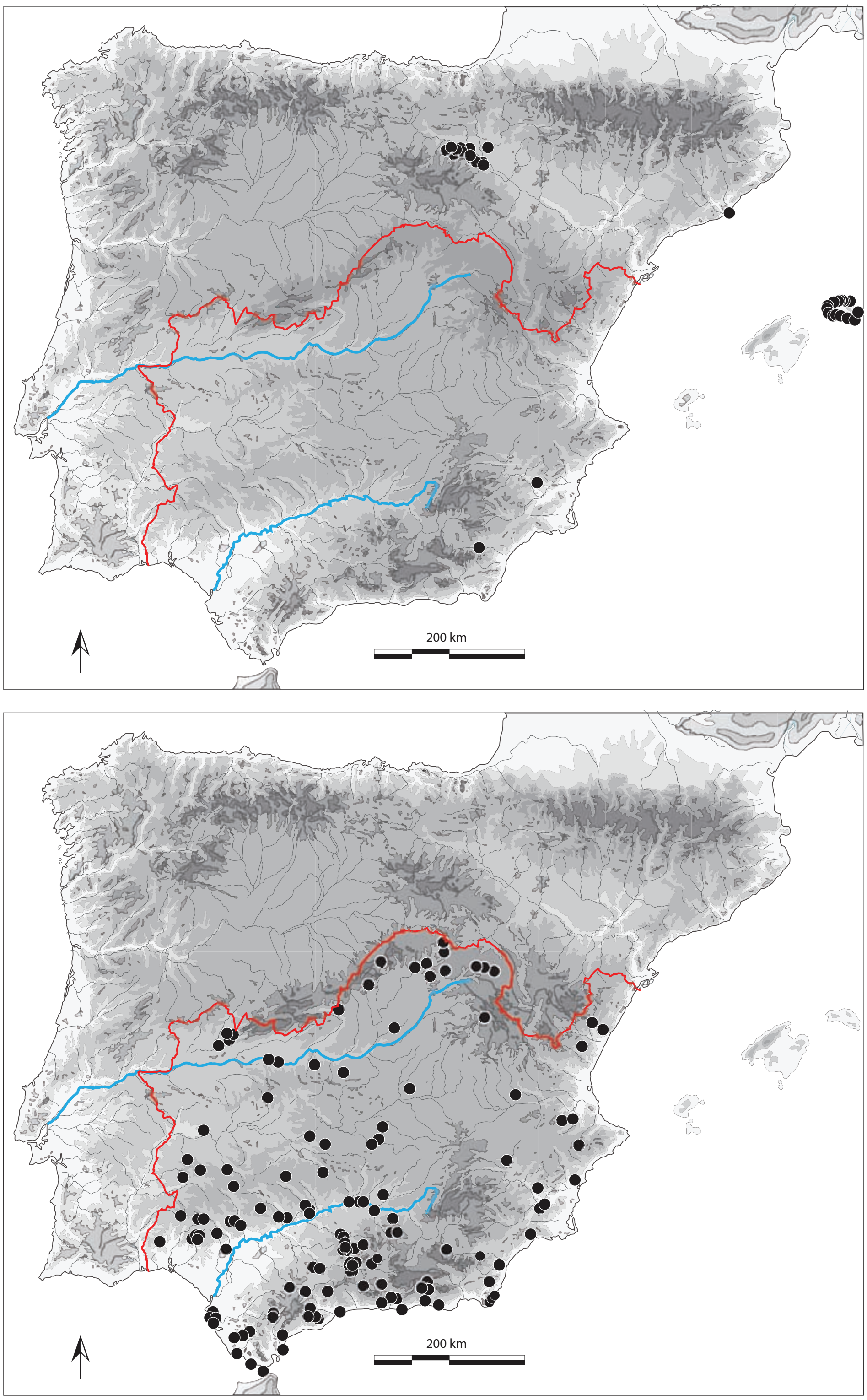


Fig. 1.1: Répartition des meulières dans la péninsule ibérique après et avant nos recherches. La concentration de sites sur la carte en haut dans la province de La Rioja est le travail de Pilar Pascual Mayoral et Pedro García Ruíz (e.g. Pascual & Ruíz 2011). La deuxième concentration sur l'île de Minorque est le travail de Joaquín Sánchez Navarro (e.g. Sánchez Navarro 2011). Seuls deux sites ont été publiés dans notre étude étaient connus avant le début de notre recherche en 2007: AL-3, Cantera de la Rambla Honda (Martínez & Granero 2005); and MU-4, Fortuna (Matilla Seiquer 2001) (dessin T. Anderson).

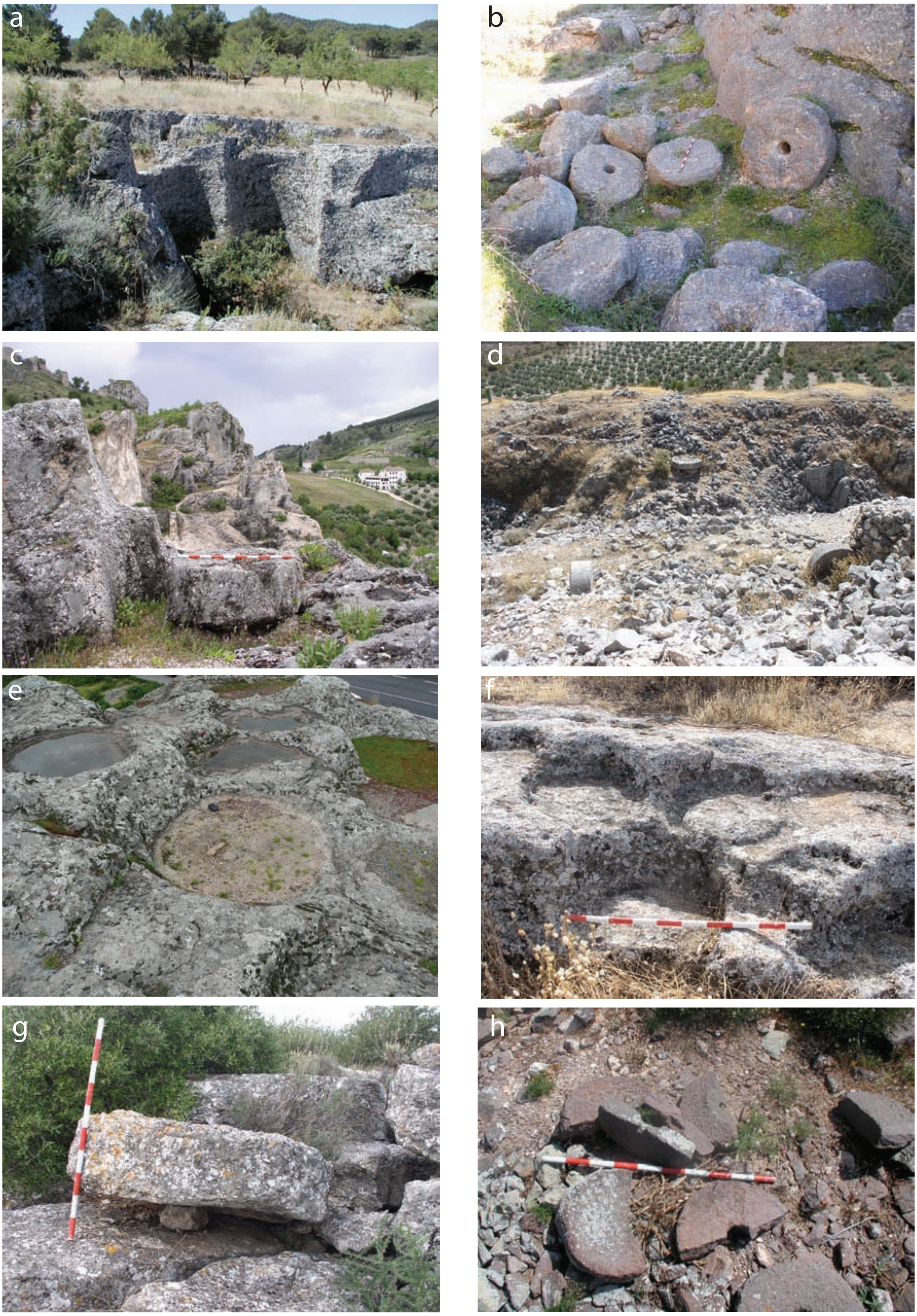


Fig. 1.2: Exemples de meulières dans le sud de la péninsule ibérique: a) Los Guillares, Padul, Granada (GR-7); b) Cantera de los Frailes, Cabra (Córdoba) (CO-1); c) Cantera, Moclín (Granada) (GR-1a); d) El Lachar, Jimena (Jaén) (J-2); e) Plasencia (Cáseres) (CC-12); f) Zagra (Granada) (GR-5); g) Teba (Málaga) (MA-2); and h) Cerro Limones (Almería) (AL-1). Les codes après le nom des sites se reportent aux numéros dans le catalogue.

Les premiers outils de mouture étaient les meules en forme de selle (ou barquiformes), actionnés par un mouvement de va-et-vient. Avec l'âge du Fer sont introduites les meules circulaires et meules entraînées par un mouvement de rotation, une avance technologique qui a été développé encore plus loin dans l'Antiquité avec l'introduction de moulins plus sophistiqués à traction animale ou hydraulique. En raison les capacités d'ingénierie des musulmans de la péninsule ibérique, les moulins à eau étaient très répandus dans le sud de l'Espagne dans les VIIIe et IXe siècles (Imamuddin 1981: 107). Plus près de nous dans le temps, le géographe Muhammad al-Idrisi, vers le milieu du XIIe siècle, décrit quatre bâtiments sur le fleuve Guadalquivir à Cordoue, chacune renfermant quatre moulins (Martínez 1987-1988: 226). H. Swinburne, dans son livre de voyages, cite la traduction d'un texte arabe de Abi Abdaalah ben Alkalhibi Abianeni de 1378 décrivant les environs de Grenade un siècle avant la chute de la domination islamique: «J'ai entendu parler de plus de trois cents hameaux dans les environs de Grenade: à la vue des remparts de la ville je peux compter une cinquantaine d'écoles religieux et lieux de culte, et plus de trois cents moulins à eau "(Swinburne 1787: 257-258). Les repartimientos de Valence, registres fonciers datant des phases initiales de la reconquête chrétienne, documentent plus d'une centaine de transferts des moulins aux colons chrétiens (Glick 1994, 982). À la lumière de tous les témoignages de moulins, on peut se demander où tous les meuniers ont acquis les milliers de meules des roches dures, compactes et abrasives qui ont joué un rôle fondamental dans l'alimentation quotidienne de l'homme.

Encore plus en détail, les dictionnaires géographiques du IXXe siècle de Sebastian Miñano (1826-1829) et de Pascual Madoz (1845-1850) (voir annexe) enregistrent des moulins dans presque chaque village en Espagne, sans oublier ceux des grandes agglomérations (voir l'annexe pour références spécifiques). K. Lizarralde, dans sa quantification des installations enregistrés dans le dictionnaire Madoz, a détaillé 22492 moulins à eau, 676 moulins à vent et 1476 *tahonas* (moulins à traction animale) (Lizarralde 2010). Si nous prenons le nombre total des moulins comptés par Lizarralde et, sur la base de deux meules pour moulin, nous atteignons un nombre de presque 50.000 meules pour le milieu du IXXe siècle. Ceci, bien sûr, est un nombre minime parce que la plupart des ces installations en possédaient plus d'une paire. En outre, ces meules n'ont pas été connues pour leur longévité car ils devaient être souvent rhabillées, parfois de manière quotidienne. Quoi qu'il en soit, en raison de la forte demande, des meulières du IXXe siècle ont du être très nombreuses et très répandues.

Il faut noter qu'à l'époque des dictionnaires de Madoz et de Miñano, la révolution industrielle n'avait pas encore atteint l'Espagne, et la péninsule était toujours sans un réseau de chemin de fer. Les pierres siliceuses françaises des districts meuliers comme La Ferté-sous-Jouarre dans le bassin parisien, qui étaient réputés les meilleurs au monde en raison de la farine blanche qu'elles produisaient, et qui ont dominé le marché européen des meules à farine, n'arrivaient pas encore en masse en Espagne. Les meuniers de la péninsule ont donc été obligés de se tourner vers des carrières locales et régionales, ce qui explique aussi l'omniprésence des meulières dans le paysage ibérique au IXXe siècle.

La situation des meulières espagnoles a changée dans la seconde moitié du IXXe siècle avec l'arrivée, d'abord, des meules françaises, puis l'abandon dans le XXe siècle du moulin à pain traditionnel. Ces meulières, souvent spectaculaires en raison de leurs hauts fronts de taille parfois marqués de multiples cavités d'extraction tubulaires, sont pour la plupart tombés en ruine. Ils ont été abandonnés, souvent envahis par la végétation, et même transformés en dépotoirs, ou pire, détruit par la construction moderne. C'est le cas du Montjuïc, près de Barcelone, jadis l'une des plus grandes et des plus célèbres meulières du basin méditerranéen occidental. La négligence de cet héritage se traduit aussi bien dans la communauté scientifique. Alors que les moulins à eau et à vent ont récemment attiré une immense quantité d'attention et provoquant des rivières d'encre, les spécialistes sont restés pratiquement muets sur les meulières qui équipaient les moulins. Cette négligence est particulièrement visible dans le sud de l'Espagne, notre zone d'étude, comme on le voit par le nombre de meulières identifiés dans des articles molinologiques avant et après que nous avons commencé nos recherches en 2007 (fig. 1.1-fig. 1.2).

Il est donc de notre intention d'entreprendre un premier bilan des meulières de la moitié sud de la péninsule ibérique, un patrimoine souvent oublié et maintenant souvent en danger de destruction par l'homme et la nature. C'est certainement un patrimoine à conserver de façon plus étendue et en tenant compte de ses nombreuses ramifications. Comme le spécialiste de meulières, Alain Belmont a récemment fait remarquer dans le résumé d'une monographie: « Tandis que les églises séculaires racontent l'histoire des croyances religieuses, et que les châteaux ruinés évoquent la puissance des élites passées, les meulières constituent autant de monuments à la gloire du travail et de la vie quotidienne" (Belmont 2006).

15.1.2. La zone d'étude

La zone d'étude comprend six communautés autonomes différentes, correspondant environ à la moitié sud de l'Espagne (fig. 1.3). Il s'agit notamment de l'Andalousie, Murcie, Castille-La Mancha, Valence, Extremadura et Madrid. A l'exception de Madrid (M) et Murcie (MU), les communautés sont sous-divisés en provinces: Andalousie: Grenade (GR), Almería (AL), Jaén (J), Cordoue (CO), Málaga (MA), Cádiz (CA), Séville (SE), Huelva (HU), Castilla La Mancha: Ciudad Real (CR), Albacete (AB), Toledo (TO), Cuenca (CU), Guadalajara (GU); Valence: Alicante (A), Valencia (V), Castellón (CS); Extremadura: Badajoz (BA) et Cáceres (CC).

D'un point de vue géographique, la région comprend un vaste secteur du Meseta (plateau) central, les montagnes de la Sierra Morena, le bassin du Guadalquivir et les montagnes bétiques. A l'ouest, la région atteint la frontière portugaise, tandis qu'à l'ouest et au sud-est, la région est bordée par l'océan Atlantique et la mer Méditerranée. Sa frontière nord correspond à peu près à une ligne est-ouest marquée par le Tage qui coule d'est en ouest. Les provinces de Guadalajara et de Castellón, les provinces les plus septentrionales des autonomies de Castilla La Mancha et de Valence, ainsi que Madrid, sont inclus car ils comprennent plusieurs sites clef d'un point de vue historique et pétrographique.

Fig. 1.3: Carte de la moitié sud de la péninsule ibérique avec les frontières des six autonomies et leurs provinces respectives. Sur la carte figurent les carrières de Palencia, Montjuïc et Macael.

15.1.3. Des recherches antérieures dans la péninsule ibérique

Comme mentionné précédemment, contrairement à la recherche sur les moulins moderns et contemporains en particulier les moulins à eau, peu de travaux ont porté spécifiquement sur des meulières. La première étude scientifique de ce type en Espagne, au Cerro Redondo à Saragosse (Cisneros *et al.* 1983) a le mérite d'inclure des analyses géologiques. Les auteurs de ce travail n'ont pas, néanmoins, envisagé la possibilité que les extractions granite porphyrique, comprises entre 60 et 80 cm de diamètre, pouvait être autre chose que des fûts de colonnes. Depuis lors, d'autres recherches se sont déroulées dans la dernière décennie. P. Pascual et P. García dans les provinces de La Rioja et Soria dans le nord d'Espagne (Pascual & García 2001-2002, 2003a-d) et J. Sánchez sur l'île de Minorque Baléares (2001, 2005, 2006) sont les véritables pionniers de recherches meulières en Espagne. Articles résumant leurs travaux ont été récemment publiés dans les actes du colloque Rome (Pascual et García 2011; Sánchez 2011), organisé par D. Williams et D. Peacock.

P. Pascual et P. García, récemment alliés avec J. Castro, ont également identifié des meulières dans le pays basque, alors que J. Sánchez récemment commencé à interroger l'île voisine de Majorque. La plupart de ces découvertes sont enregistrées dans l'atlas des meulières (eu.millstonequarries) disponibles sur Internet (http://meuliere.ish-lyon.cnrs.fr).

En ce qui concerne des meulières de l'âge du fer, il y a deux articles qui se touchent brièvement la question. La première est celle de Checa *et al.* (1999) sur les meules de Numance (Soria). Le second est le travail de l'équipe dirigée par N. Alonso (2011) sur les meules de l'habitat de Els Vilars (Catalogne). Pour des périodes plus récentes de la Catalogne, M. Sancho (2008) a noté brièvement la présence d'une meulière à Vilamolar (Lleida) dans son étude sur l'exploitation des ressources naturelles à l'époque médiévale, et A. Gutiérrez (2009), dans son étude des anciennes carrières de construction, a brièvement décrit la production de meules du Montjuïc à Barcelone, la carrière de meules de loin la plus célèbre de la péninsule ibérique (fig. 1.4-5).

Loin de l'Espagne continentale, mais non dénué d'intérêt, est le travail de l'équipe de A. Rodríguez sur les meulières volcaniques des Guanches, les habitants précoloniaux de l'île de Tenerife dans les îles Canaries avaient qui extraient des meules rotatives en roche volcanique avec des outils de pierre.

Une des œuvres les plus complètes dédiées spécifiquement à l'industrie meulière est la récente courte monographie de J. Maestro Hernández (2011), basée en partie sur un travail de prospection de terrain, de données recueillies dans des archives, ainsi que d'entrevues avec les descendants des fabriquants de meules des montagnes de Palencia, dans le nord d'Espagne.

Dans notre zone d'étude, les articles suivants ressortent: Matilla (2001) sur une carrière à Fortuna (MU-4) en Murcie qui fabriquait surtout de rouleaux pour l'industrie de l'huile; Montero (2008) sur la spectaculaire meulière de *rosso ammonitico* de Los Frailes près de Cabra (CO-1) dans la province de Cordoue; Martínez et Granero (2005), ainsi que la version révisée (Martínez *et al.* 2011) sur une meulière de conglomérat près de Albox (AL-3) (Almería); Altamirano et Anton (2012) sur le site Patriarca (CO-12) à la périphérie de la ville de Córdoba; et Molina et Cultrone (2012) sur la provenance des meules de contextes archéologiques à Baza (Granada). Aucun de ces travaux, néanmoins, va au-delà du domaine de l'étude de cas.

L'épine dorsale de notre étude, néanmoins, est la recherche que nous avons entrepris depuis 2007. Cette recherche comprend des données provenant d'une série de rapports non publiés basée sur des études de meules entreposées dans des dépôts de musées provinciaux et municipaux comme Priego de Córdoba et Almedinilla (Cordoue); Baelo Claudia (Cádiz); Vélez Rubio et Almería (Almería) ; Málaga (Málaga); Baza (Grenade); Murcie et Linares, Ubeda et Alcalá la Real (Jaén), et Mérida (Estrémadura).

En plus de ces rapports non publiés, nous avons publié plusieurs articles sur le sujet de meulières ibériques de la Protohistoire au Moyen Âge. Un premier article est sortie dans les actes du colloque de Saint Julien sur Garonne en France (Anderson 2011), suivie par deux articles dans les actes du colloque de Rome, le premier étant une collaboration avec les géologues T. Grenne de l'NGU norvégien et J.-M. Fernández Soler de l'Université de Grenade, sur le thème de la production de meules dans l'Antiquité dans les provinces volcaniques de Cabo de Gata (Almeria) et de Campo de Calatrava (Ciudad Real) (Anderson *et al.* 2011). Le second article s'agissait d'un bilan général des meulières dans le sud de l'Espagne, une collaboration avec le géologue J. Scarrow de l'Université de Grenade, en mettant l'accent sur les productions modernes et contemporains identifiés à travers l'internet et la consultation des textes anciens. Deux autres articles sont actuellement en attente de publication. Le premier, soumis aux actes du colloque tenue en 2011 à Lons-le-Saunier, France, est une collaboration avec l'archéologue L. Jaccottey (INRAP, France) et le géologues J. Scarrow et A. Cambeses de l'Université de Grenade, et examine la question de moulins pompéiens dans la péninsule ibérique. La seconde, une étude diachronique des meules manuelles rotatives et leurs carrières dans le sud de l'Espagne, en collaboration avec J. Scarrow et A. Cambeses, a été soumis aux actes du colloque de Bergen (fin 2011), en Norvège.

Cette étude a bénéficiée également de données inédites issues de ma participation à la fouille de trois meulières en France à Claix (Charente) et au Mont Vouan (Haute-Savoie) sous la direction de A. Belmont (Université de Grenoble, LARHRA), ainsi que l'étude, en collaboration avec A. Hauken Dahlin, des anciennes meules rotatives stockées dans le Musée de Stavanger, Norvège. Ce dernier projet, une monographie encore sous presse, a été effectuée le cadre du projet de recherche Norwegian Millstone Landscapes (dirigé par G. Meyer, T. Heldal et T. Grenne).

15.1.4. Terminologie: moulins, meules et carrières

Le terme anglais «*millstone*» dans cette étude, selon le contexte, est utilisé à la fois dans son sens le plus large et étroit. "*Millstone*" au sens large comprend tout type de meule, de la meule barquiforme à va-et-vient du néolithique, au moulin à bras rotatif, et aux grandes meules lourdes conduites par la force hydraulique. Dans son sens le plus étroit "*millstone*" équivaut aux grandes meules de moulins à eau. Les termes équivalents en espagnol (*muela*) et français (*meule*) se réfèrent également à tous les types de pierres, de néolithique jusqu'à l'époque contemporaine. Tous ces termes sont parfois ambigus, nous laissant avec la doute s'il s'agit d'un moulin à bras ou à un moulin à traction plus sophistiquée. La langue anglaise bénéficie du mot "*quern*" pour spécifier le plus petit moulin manuelles. Ainsi, dans cet ouvrage, «*quern*» est toujours reservé au moulins manuelles et «*millstone*», le plus souvent, réservé à des meules de mécanismes plus grandes avec les systèmes de traction plus complexes tels que des moulins à sang ou des moulins à eau et à vent.

Le terme «carrière» se définit simplement comme un lieu où la pierre est extraite. En anglais, le terme «*quarry*» appliquée à l'extraction de pierre meulière est, en un certain sens, un abus de langage. Selon l'*Oxford English Dictionary*, le mot a une origine qui évoque une forme carrée, loin de celle de la meule circulaire. En dépit de l'ironie de l'origine du terme, il est adopté dans son sens général comme un lieu où les meules sont extraits. Les langues espagnole et française, contrairement à l'anglais, bénéficient des noms précises for designer des carrières de meules (*molera* et *meulière*).

Pour cette étude, le terme «*quarry*» ne comprend pas seulement l'endroit où la pierre est extraite directement de la masse rocheuse (par coupure directe ou détachement), mais précise également les endroits naturels, tels des éboulis ou des talus au pied d'une pente, un lit de rivière, ou encore un ravin où les roches ont été à plusieurs reprises récoltées pour fabriquer des meules.

En ce qui concerne le personnel des meulières, il existe des termes spécifiques en espagnol et en français (*molero* et *meulier*) pour désigner la personne qui fabrique des meules. Une des images rares de *moleros* «au travail» en Espagne est celui de la de la carrière de Brañosera dans les montagnes de Palencia (fig. 1.6). En espagnol, le terme *molero* s'applique aussi, parfois, au marchand de meules.

15.1.5. Cadre chronologique

En raison de l'état embryonnaire de la recherche sur les meulières et sur les meules elles-mêmes, ces site ne peuvent être placés, au mieux, que dans les grandes niches chronologiques. Une grande partie de sites défient un classements et peuvent tomber dans plusieurs périodes. Pour notre étude, nous avons adopté le système de datation traditionnelle utilisée pour le sud de l'Espagne.

Les exploitation de meules le plus anciennes datent de la fin du Néolithique, vers 3000 avant J.-C. Ces productions de meules à va-et-vient sont accessoires à notre étude et paraissent ici parce qu'elles sont, vraisemblablement, aussi les sources de meules manuelles romaines. Un de ces sites date de la transition du chalcolithique et de l'âge du bronze, à peu près entre 2000 et 1500 avant J.-C. La source des meules de l'âge de Fer tardif date du milieu du IIe siècle avant J.-C. dans la culture ibérique en contexte de l'« *hinterland* ». Elle est suivie par une série de sites romains s'étendant sur plusieurs siècles à partir du IIème siècle avant J.-C. jusqu'à environ IVe-Ve siècle de notre ère. Le passage de l'Antiquité tardive au début du Moyen Âge, marqués par la domination germanique, est floue et certaines productions attribuées à la période romaine pourrait en fait être des VIe et VIIe siècles. Malgré des grands changements politiques et sociaux qui ont eu lieu au Moyen Âge avec le début de la domination islamique en 711, cette longue période ne se reflète que globalement dans la typologie des meules et leur production. L'expulsion du dernier souverain musulman de Grenade en 1492 marque la fin du Moyen Âge. La Reconquête, cependant, était un long processus qui explique la série de documents historiques en castillan qui datent d'avant la chute de Grenade. Les quelques siècles de la période moderne voit une légère augmentation des carrières documentées par des sources écrites. C'est l'arrivée de la période contemporaine, en 1789, basé sur la Révolution française, qui marque la plus forte production de meules, souvent cités dans les dictionnaires de la première moitié du XVIIIe siècle.

15.1.6. Les problèmes d'identification de meulières

Différencier des carrières produisant des meules à grains des autres carrières avec extractions cylindriques (tambours de colonnes, des rouleaux de huile, pierres à aiguiser) n'est pas nécessairement une tâche simple. Les ébauches, les alvéoles d'extraction et les marques d'outils de tous ces types de produits sont identiques.

La carrière de Cerro Bellido (voir catalogue, SE-4) dans la province de Séville est un exemple. Le site est réputé pour son exploitation à l'époque romaine de tambours de colonnes (fig. 1.7). La roche est un calcaire grossier et poreux, semblable aux roches souvent choisis pour des meules. Les traces diagonales parallèles d'extraction sur les fronts de taille sont identiques à celles observées dans des meulières. La principale différence est que les ébauches, d'un diamètre (1,00 m) compatible avec beaucoup de meules, sont proportionnellement plus épaisses que les ébauches de meules.

Dans ce cas particulier, des meules abandonnées trouvées dans le lit de la proche rivière de Yeguas, a conduit les historiens locaux à spéculer que des "tambours" non utilisés à la Cerro Cerrido ont été recyclés à l'époque médiévale comme meules (F. Estepa, comm. pers.).

La dernière génération de broyeurs pour les *almazaras* (huileries), aujourd'hui souvent décorant les lieux publics dans sud de l'Espagne, sont de grands cônes de granit, habituellement plus de 1 m de diamètre à leur base. En raison de leur forme conique, il n'y a pas de confusion possible avec des meules cylindriques. Il y a, cependant, des huileries plus anciennes, par exemple au moulin du XVe siècle de Nigüelas (Granada), qui était équipé des rouleaux cylindriques ou légèrement tronconique qui tournaint à la verticale (fig. 1.8). Selon le type de roche et de leur forme, des carrières des rouleaux pour *almazaras*, dont au moins une douzaine sont identifiés dans notre zone d'étude dans le dictionnaire de Madoz (1845-1850), pourraient être difficile à distinguer des meulières pour des meules de céréales.

Des carrières de pierres à aiguiser de forme cylindrique, un outil commun comme l'exemple dans le tableau de Goya (fig. 1.9), sont également difficiles à distinguer des meulières de céréales. Des anciens textes géographiques indiquent que ces exploitations (*amoladeras*) étaient abondantes. La plus célèbre dans notre zone d'étude, citée dans les textes anciens, se trouvait autour d'Alhambra (Ciudad Real) (Benítez de Lugo 2001: 13). Montoro (Cordoue) est également réputé pour ses pierres à aiguiser en *Bundsandstein* rougeâtre fin (*piedra molinaza*) (Clementson 2012: 3-5). Toutefois, à travers les archives historiques, nous savons que les meules à grains rougeâtres ont également été tirées à Montoro (CO-14) (Córdoba de la Llave 1988: 843, note 22).

Enfin, d'autres industries telles que l'industrie de canne à sucre du IXXe siècle le long de la côte de Grenade, ont également employé des meules. Les broyeurs en *grès coquillier* exposés dans le jardin du château de Almuñecar (fig. 1.10) ont certainement été importés de carrières de la région de Cadix. Ces cylindres de taille moyenne pourraient ainsi facilement être confondus avec des meules médiévales.

Sur le terrain, interpréter des alvéoles circulaires est aussi problématique. Certaines extractions circulaires ont été interprétées comme des cavités d'évaporation de saumure pour la production de sel, abreuvoirs des animaux, symboles du soleil préhistoriques ou des marques de délimiter les limites de propriété (fig. 1.11).

Enfin, des meulières où des blocs angulaires ont été détachés pour la fabricatioin de meules composites (assemblées avec du plâtre et fixés par des bandes de fer), laissent peu d'indices dans le terrain.

15.2. Sources, les ressources et les travaux sur le terrain

De toutes les différentes sources disponibles pour identifier les meulières, les plus précieuses sont ces dictionnaires géographiques et autres sources écrites datant de la fin du XVIIIe siècle jusqu'au milieu du IXXe siècle. Les travaux effectués à l'échelle nationale de S. Miñano (1826-1829), P. Madoz (1845-1850), et leurs collaborateurs, sont les sources du plus grand nombre de sites présentés dans cette étude (un peu moins de la moitié). Il faut noter que l'ensemble signalé par Madoz (environ 40) est beaucoup plus grand que celui de Miñano (5). Nous avons néanmoins retenu l'importance de la contribution de Miñano pour que de futurs chercheurs soient conscients de la validité de son travail, surtout dans le nord de l'Espagne, en dehors de notre zone d'étude.

D'autres œuvres de caractère régional, comme les histoires de García de la Leña (1789) pour Málaga, celle de Martínez y Delgado (1875) pour Medina Sidonia, Cadix, ainsi que quelques travaux géologiques anciens tels que ceux d'Ezquerra del Bayo (1856), avancent également des données pertinentes sur des meulières.

Fig. 2.1: Page de couverture du Diccionario Geográfico-Estadístico-Histórico de España y sus Posesiones de Ultramar, 16 vol., 1845-1850, publié sous la direction de Pascual Madoz.

Dans l'ensemble, ces sources représentent presque la moitié des sites que nous avons pu identifier. Néanmoins, malgré leur importance pour notre recherche, ils ne servent, pour la plupart, que pour identifier la municipalité d'une meulière et n'offrent que rarement plus que de brèves informations sur la production d'un site. En ce sens, ils servent surtout de points de départ pour lancer la recherche.

Comme ailleurs en Europe, notamment en France, les sources historiques telles que les décrets royaux, arrêtés municipaux ou les protocoles de notaires identifient également les productions de meules, et parfois fournissent des données, bien que généralement très restreintes, sur les distances de commercialisation, les moyens de transport et les diamètres des meules. Ces documents sont aussi parfois utiles pour établir la chronologie de certains sites, par exemple pour la période après la domination islamique, de la fin du Moyen Âge à l'époque moderne, avant l'avènement des traités géographiques et géologiques du IXXe siècle.

Il faut noter que, dans le cadre de notre recherche, les archives historiques ont à peine été exploitées comme sources primaires, une tâche au-delà de nos moyens qui aurait nécessité des semaines ou même des mois dans les archives locales, fouillant dans de vieux documents écrits en ancienne calligraphie castillane. Les sources que nous avons citées, sauf quelques-unes qui sont disponibles sur Internet ou sous forme de DVD, sont le fruit de recherches molinologiques entreprises par des autres historiens. En ce sens, il convient de noter le travail du médiéviste Córdoba de la Llave sur les moulins à eau de la ville et de la province de Cordoue.

Cela dit, un grand nombre d'archives textuelles privées, nationales, provinciales et municipales sont toujours en attente d'être exploitées dans la perspective d'une étude de carrières de meules. Les archives privées de la famille aristocratique du Duc de Medina Sidonia à San Lúcar de Barrameda, Cádiz, par exemple, vont certainement apporter des donnés sur la vaste meulière de El Berrueco (CA-8), une exploitation que la famille comptait parmi ses possessions pendant au moins plusieurs siècles. Des recherches plus poussées dans les archives du Duc de Medina Sidonia vont peut-être éclaircir la relation entre la meulière de El Berrueco et un certain nombre de moulins à eau, notamment ceux de la ville de Vejer de la Frontera, appartenant aussi à la famille du Duque de Medina Sidonia. Un écrivain en 1813 a noté que le Duc était rémunéré avec 18 meules par an pour la concession de meules à Berruecos (Cruz y Bahamonde 1813, 91, note 1). Nous pensons qu'une rémunération en meules était, peut-être, plus intéressante pour le Duc qu'en espèces, car il a pu s'en servir pour remplacer les meules de moulins à eau dont il était le propriétaire.

Depuis les quelques années qui se sont écoulées après le début de cette étude, l'accès à des sources écrites comme des vieux dictionnaires géographiques et des articles molinologiques, a grimpé en flèche. Lorsque nous avons commencé notre étude, par exemple, seuls quelques-uns des 16 volumes du dictionnaire Madoz n'étaient que partiellement disponibles sur l'internet dans un format qui pouvait être utilisé au moyen de la reconnaissance optique de caractères (OCR). Par conséquent, à cette époque, nous avons été obligés de lire plusieurs volumes, mot pour mot, cherchant même l'allusion la plus éloignée à une carrière de meule. Cette première lecture des textes, une tâche extrêmement lourde, a néanmoins fourni des informations sur comment, et dans quelles rubriques, Madoz enregistrait des meulières, information qui a bien servi à partir du moment où les documents sont devenus accessibles pour réaliser des recherches par mots clefs.

La recherche parmi les textes historiques demandait de développer certaines compétences d'un historien-paléographe. Comme archéologue, j'étais évidemment plus à l'aise en examiner des meules dans les dépôts de musées. En tout cas, les deux lignes de recherche vont de main en main en ce qui concerne la recherche sur de meulières, car d'une manière générale, la première apporte des informations sur des productions modernes et contemporaines, tandis que la seconde fournit des données plus âgées, de la Protohistoire à l'Antiquité.

L'information recueillie à partir des études de meules dans des collections des musées sert non seulement à établir une classification générale des meules, mais aussi, parfois, à identifier des districts meuliers. Les 40 meules en biocalcarenite « *ostionera* » dans la ville romaine de *Baelo Claudia*, par opposition à une seule importation en roche volcanique, montrent clairement l'exploitation de la roche locale dont les affleurements sont situés le long de la côte de la baie de Cadix. Les nombreuses meules volcaniques conservées au sein de la collection du Musée Archéologique de la Provincia de Murcia suggèrent des exploitations des affleurements volcaniques locaux et régionaux. De la même manière, une majorité de meules en granit du Museo Nacional de Arte Romano de Mérida est l'indice d'une exploitation de la roche dominante de la région.

Certaines meules étudiées dans les musées peuvent signaler également des centres de production de meules spécifiques. Les ébauches en lamproïte à Murcia, recueillies auprès de la municipalité de Mazarrón, peuvent être attribuées à un affleurement de lamproïte à Cabezo de la Oliva (MU-2), à une courte distance de la villa romaine où les ébauches ont été découvertes. De même, une série d'ébauches du Musée d'Almería désignent les meulières du Cabo de Gata qui ont été, d'ailleurs, confirmées sur le terrain (AL-1 et AL-2).

Bien que les sources écrites et les meules dans les dépôts des musées sont une riche source d'informations sur les meulières, elles sont limitées presque exclusivement aux cadres chronologiques allant respectivement de la Préhistoire à l'Antiquité et à partir de la fin du Moyen-Age au IXXe siècle. Par contre, ils ne fournissent que peu de données sur le Moyen-Âge, entre la domination gothique jusqu'à la fin de la domination islamique. Cette lacune se fera sentir tout au long de cette étude.

Une troisième source pour identifier les meulières, qui s'avère extrêmement utile, est « non conventionnelles ». Un certain nombre de sites ont en effet été identifiées à la suite de consultation d'un nombre croissant d'itinéraires de randonnée affichés sur internet, et souvent accompagnés de descriptions de paysages et de photographies des différentes « curiosités » (c.-à meulières) le long de leurs pistes. Les sites de Lanchar, (J-2), El Berrueco (CA-8), Peña Harpada (CA-10), Soneja (CS-1) sont des exemples. Comme nous l'avons noté dans le chapitre 8 sur l'infrastructure des carrières, les anciens productiosn de meules ont souvent été servis par les pistes, sentiers ou routes, dont certaines ont perduré jusqu'au nos jours et se sont intégrés dans les sentiers de randonnée.

D’autres indices sur internet, tels que les photos et vidéos, sont aussi des outils pour identifier des meulières. La site médiévale de Almaden de la Plata (SE-1) n’aurait été jamais connue sans un entretien publié sur l’internte avec l’archéologue Miguel de Vargas. Internet fournit également aux historiens amateurs une plate-forme pour publier des informations détaillées sur leurs municipalités. Nous saurions peu de choses sur le tailleur de pierre Juan de Bargas du début du XVIIe siècle et sur la meulière d’Albardado (C-10), si des recherches n’avaient pas été publiées sur internet par une équipe d’étudiants de l’école secondaire de la ville de Pozoblanco à Córdoba (González Peralbo 2008 site web).

En bref, l’ensemble des sources conventionnelles et non conventionnelles s’agissant des indices préliminaires. Les sites identifiés par ces moyens requièrent confirmation et descriptions, une tâche qui ne peut par être réalisée sans une reconnaissance sur le terrain. Dans notre étude, ces confirmations sur le terrain des meulières ont été réalisées pour environ un tiers (48) des sites sur un total de 138.

Dans de nombreux cas, en raison du peu d’informations sur l’emplacement d’un site, et pour éviter de perdre du temps, nous nous sommes appuyés sur les contacts locaux (amateurs et les historiens locaux) pour nous guider aux sites. Dans d’autres cas, nous avons renoncé à une reconnaissance de terrain, soit parce que le site était trop loin de notre base, soit parce que les informations de sa localisation étaient trop peu précises, et nécessitaient possiblement des jours des prospections. En somme, il est évident que si nous avions été en mesure de explorer plus de sites sur le terrain, nos résultats seraient plus amples et auraient permis de tirer des conclusions plus précises.

Les travaux de terrain que nous avons pu effectuer nous ont permis de recueillir des informations qui n’étaient pas disponibles à partir des sources, telles que les données sur les techniques d’extraction (jamais décrites dans les sources écrites), le volume de production et la présence ou non de différentes phases de production. Les visites des sites ont également permis de recueillir des échantillons de roches pour certaines analyses pétrographiques et géochimiques. Sur l’ensemble, il faut noter, toutefois, que nos visites étaient malheureusement trop courtes et entreprises sans moyens d’enregistrer ou de prendre des mesures précises afin d’effectuer des relevés à l’échelle. Cet aspect a été particulièrement frustrant à cause de mon passé d’archéologue de terrain.

15.3. Les produits des meulières et leurs installations

Le chapitre 3 marque une légère « digression » vis-à-vis de l'objet principal de cette étude, les meulières. Nous décrivons brièvement les différents types de moulins avec leurs mécanismes ou installations depuis les meules barquiformes aux grands moulins à eau avec leurs système complexe d'engrenages. Ces descriptions sont basées, pour la plupart, sur des observations faites dans les dépôts de musées, ainsi que sur les descriptions de la littérature molinologique. Il est évident que la compréhension des meules, leur datation et leur évolution vont de pair avec la compréhension de l'évolution des carrières de meules. Étant donné que les différents types de meules, leurs aménagements et leurs moyens de traction ont été décrits dans le chapitre 3, nous allons nous limiter ici à les placer dans le cadre de la classification de meulières proposée dans le chapitre 6.

En ce qui concerne le thème de l'introduction de technologies innovantes, la datation du passage du mouvement va-et-vient au mouvement rotatif dans notre zone d'étude, contrairement au cas de Catalogne (datant du milieu du Ve siècle av. J.-C.), ne peut pas être identifiée à ce stade de la recherche. Il semble néanmoins que l'arrivée du mouvement rotatif, comme dans le cas de la Catalogne, coïncide tant avec des petites meules rotatives que des grands moulins à sang. C'est une différence majeure avec l'introduction du mouvement rotatif en Europe centrale qui est représenté uniquement par les moulins rotatifs manuels. Il est également logique de supposer, bien que les preuves soient rares, que l'introduction de moulins hydrauliques a eu lieu sous la domination romaine et que les moulins à vent ont été introduits bien plus tard, au Moyen Âge.

Les descriptions des différents types de meules présentées au chapitre 3 ne représentent que des notions générales, et ne peuvent pas être considérées comme une classification typologique formelle. À notre avis, à ce stade de la recherche, les conditions ne sont pas réunies

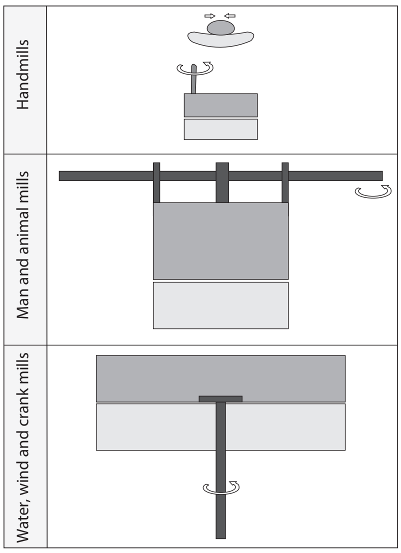


Fig. 3.1: Représentation schématique des trois principaux types de moulins à céréales produits dans des carrières, en fonction de leurs forces motrices: moulins manuels actionné par le bras; », moulin à sang, à eau et à vent (entraînés par les forces naturelles) (dessin T. Anderson).

pour établir une typo-chronologie exhaustive des meules dans le sud de l'Espagne. Bien que des avancées positives aient été réalisées pour la période romaine, le corpus de meules de toutes les autres périodes est trop peu nombreux, que ce soit dans les collections de musées ou dans la littérature archéologique. En outre, il y a encore trop peu d'assemblages bien datés à partir desquels formuler des statistiques empiriques.

15.3.1. Moulins à va-et-vient

Ces premiers modèles de moulins à céréales sont typiques des villages depuis le Néolithique jusqu'au milieu de l'âge du fer. Ils sont fréquents sur des célèbres habitats préhistoriques tardifs comme Los Millares (Almería) ou des sites de l'âge du Fer précoce comme Cancho Roano (Huelva). Ils ont été utilisés pour moudre un certain nombre de denrées alimentaires, ainsi que d'autres produits tels que des pigments, comme on le voit à partir des traces d'ocre rouge (*almagra*) à Los Pensadores, Grenade (Anderson 2010, inédit).

La plupart des meules à va-et-vient sont en schiste, granit et grès et étaient recueillis en surface (meulière de type MQ-1a), auprès des lits des rivières, des ravins et des talus, selon toute vraisemblance, situés près des habitats. Il y a aussi des indices, encore mal documentés et hypothétiques, de que ceux meules ont été extraites dans des meulières sous forme de petits blocs (MQ-2b). Deux sites de ce genre (Los Pensadores, GR-12; Cabezo de Oliva, MU-2) ont été identifiés, car ils coïncident (vraisemblablement) à la production quelques siècles plus tard de meules manuelles romaines. Le troisième site, EL Barronal (AL-10), dans le district volcanique de Cabo de Gata (Almería), a vraisemblablement livré des meules en au moyen de détachement des blocs des sommets de colonnes volcaniques (*columnar jointing*) (Carrión 1993; Haro Navarro *et al.* 2006). Pour des informations plus spécialisées sur le thème de la production de meules à va-et-vient dans ces périodes anciennes pour notre zone d'étude, nous nous référons aux travaux de Carrión *et al.* (1993), Risch (1995), Haro Navarro *et al.* (2006) et Delgado Raack (2008).

Un aspect à retenir, qui est associé au thème des moulins actionnés par le mouvement à va-et-vient, est l'absence dans notre zone d'étude du moulin à trémie de type Olynthe. Cette absence appuie les hypothèses que la sphère de diffusion de ce type de moulin se concentre dans la Méditerranée orientale. Les exemples les plus au sud de la péninsule ibérique se situent au naufrage d'El Sec au large de la côte de Majorque (Arribas 1987), à Lattes dans le sud de la France (Py, 1992) et Rhodes (Girone) en Catalogne (Genís 1986, 113).

15.3.2. Moulins rotatifs de l'âge de Fer

Les meuliers de l'âge de Fer ont fabriqué autant de meules rotatives manuelles que de grands moulins à sang. En fait, les deux types partagent essentiellement la même morphologie, soit une forme cylindrique et des divers aménagements, ainsi que des mêmea roches. La différence était dans le moyen de traction. Les plus petits modèles « domestiques », environ 35 cm de diamètre en moyenne, ont été actionnés, comme on le voit dans les études ethnologiques, en position assise et au niveau du sol. Les modèles plus grands (à sang), d'environ deux fois leur diamètre (souvent découverts *in situ* sur les podiums) ont été quant à eux actionnés depuis une position debout. De toute évidence, les modèles plus grands ont donné un volume plus important de farine et, selon toute vraisemblance, servis au-delà du cadre familial. Des amánagement tels de « trous de serrure inversés » ou « en forme de L » latéraux, des éléments typo-chonologiques caractéristiques, étaient présents sur les deux modèles.

En Catalogne et en Valence, ces modèles se trouvent dans des contextes depuis le milieu du Ve siècle av. J.-C. (Alonso, 1999), et représentent au moins l'une des premières manifestations du mouvement rotatif dans l'histoire de la mouture. Dans le sud de l'Espagne, par contre, il n'y a pas de si anciens modèles. C'est énigmatique, surtout compte tenu du degré de travail de la pierre (architecture, statuaire) dans la culture ibérique du sud de la péninsule. Par conséquent, il n'est pas toujours clair si l'absence de modèles rotatifs dans des contextes anciens est due à l'état de la recherche, notamment l'absence de fouilles modernes de phases anciennes de la culture ibérique, ou si les ibères du sud étaient réticents à adopter cette nouvelle technologie.

À l'heure actuelle, il n'existe aucune preuve tangible que des meules aient été produites à l'âge du Fer dans les meulières à extraction directe (MQ-2). Les exemples en granite et en conglomérat reflètent probablement un travail sur des blocs de surface (MQ-1a). Les exemples de Numance (Soria) sont pour la plupart des modèles manuels à section hémisphérique proviennent vraisemblablement des blocs de surface qui se situent dans un rayon de quelques kilomètres autour de l'habitat (Checa *et al.* 1999).

Dans la région de la Sub-Bétique, il y a une nette préférence pour le calcaire tufier (appelé communément « travertin »), une roche très poreuse trouvée dans des contextes humides riches en carbonates. Cette roche a été exploitée autour d'Almedinilla (Córdoba) et pour des meules pour de habitat de l'âge du Fer situé non loin de Cerro de la Cruz (Quesada *et al.* 2010). Il est possible que les fabricants de meules aient profité des blocs de surface détachés des grandes formations de tuf (MQ-1a). Toutefois, en raison de la faible dureté de la roche qui se laissait couper facilement, il ne peut être exclu que certaines meules fussent taillées directement à partir de la masse rocheuse dans de « véritables » carrières d'extraction (True extractive quarries, MQ-2a). Récemment, une carrière romaine utilisant cette roche pour des matériaux de construction a été identifiée dans la région d'Almedinilla (Muñiz 2012). Cette récente découverte pourrait indiquer qu'une production de meules plus ancienne pourrait être conservée dans la région.

Il est à noter qu'aucune meulière à extraction directe de l'âge de Fer (MQ-2a) n'a encore été identifiée en Europe. Les travaux d'extraction directe qui laissent des creux circulaires dans la roche (MQ-2a) n'ont en effet été introduits qu'à l'époque romaine d'après l'état de la recherche actuelle. Cette notion a déjà été avancée par Runnels (1981: 72). Les récents travaux de L. Jaccottey reposant sur les découvertes de sites en France et en Suisse renforcent de surcroît cette notion. À titre d'hypothèse, il ne serait pas surprenant, cependant, que de futurs travaux dans le sud de l'Espagne mettent en lumière de véritables meulières extractives précoces employant la technique d'extraction directe qui a une longue tradition dans l'ensemble du bassin méditerranéen.

Il est également intéressant de noter qu'il n'y a aucune preuve dans notre zone d'étude d'exploitation de roches volcaniques durant l'âge du Fer. Cela contraste avec la situation en Catalogne où les roches volcaniques, probablement celles du district volcanique d'Olot-Garrotxa dans la province de Gérone, ont été exploitées pour des meules rotatives, dès le milieu du Ve siècle av. J.-C. (Ca n'Olivé, Alonso 1999: 262, fig . 171).

15.3.3 Moulins romains

La conquête romaine est accompagnée d'une diversification des moulins actionnés par l'homme, par des animaux et, vraisemblablement, par la force hydraulique. Les moulins manuels et les grands moulins cylindriques à sang semblent avoir évolué depuis les modèles de l'âge du Fer de tradition indigène, alors que les moulins de type Pompéi et des moulins à eau, faiblement représentés en Espagne, sont pour la plupart des importations. La matière choisie pour fabriquer les meules change également avec l'introduction de matière volcanique à grande échelle. Au niveau de techniques de production, un grand bond a été réalisé avec l'introduction de véritables meulières extractives (MQ-2a).

Moulins manuels romains

Les meules manuelles romaines, bien représentées dans les collections des musées, ont été façonnées à partir d'une variété de roches telles des biocalcarenites, granites, grès, ainsi que d'une variété de roches volcaniques (dacites, rhyolites, lamproïtes, basaltes).

La production a pris la forme d'exploitations de blocs anguleux (MQ-2b), tels que le Cerro de Limones (Al-1) et Hoya del Paraíso (AL-2) dans le district SE volcanique, où ils ont été détachés des sommets des colonnes volcaniques au moyen de leviers (MQ-2b).

Elles ont également été fabriquées dans de véritables meulières d'extraction (MQ-2a) comme les biocalcarenites taillées directement du socle rocheux sur des sites du littoral de Trafalgar (CA-1) et de Rota (CA-3). Mais les meulières d'extraction directe ne se limitent pas à des pierres sédimentaires. Les moulins manuels ont eux aussi été tirés des coulées de lave des dômes volcaniques en dehors de la ville romaine de Sisapo (CR-1) laissant les caractéristiques alvéoles circulaires.

Le système de production de meules romaines en granit n'est pas connu. Certaines meules de cette roche ont sans doute été façonnées à partir de matériau de surface (MQ-1a). Il ne peut être exclu que des grands blocs aient été exploités comme des meulières extractives (MQ-1b) ou que des affleurements extensifs aient été exploités en meulières d'extraction directe (MQ-2a).

Moulins cylindriques romains

Les moulins cylindriques romains, avec leur *catilli* en forme d'anneau et leur *metae* en cloche, connus par des exemples dans la ville romaine de *Volubilis*, au nord du Maroc, sont en fait très courants dans le sud de l'Espagne. Leur rôle dans l'histoire de la meunerie n'est pas encore clairement défini. Ils sont souvent associés à l'industrie de l'huile d'olive, comme on le voit à travers un certain nombre d'exemples qui ont été mis au jour lors de fouilles dans, ou à proximité de pressoirs (Peña Cervantes 2010: 66).

La recherche récente de Peña Cervantes (2010), comme celle de Frankel avant elle (1999), associent ces meules avec la *mola olearia* de Columelle, le moulin qui broyait les olives en pâte avant qu'elles soient pressées pour en extraire l'huile. Pour corroborer ce point de vue, Peña Cervantes se fonde sur les recherches à *Volubilis* (Akerraz & Lenoir 2002), sur les enquêtes de Ponsich dans la vallée du Guadalquivir (1974, 1979, 1987, 1991), et sur de récentes fouilles archéologiques (Peña Cervantes 2010: 36). En outre, ce type de moulin (contrairement au rouleau vertical) offrait la possibilité de régler l'espace entre les meules afin de ne pas écraser le noyau de l'olive, une action, selon Columelle, qui réduisait la qualité et le goût de l'huile (Peña Cervantes 2010: 39, note 50). L'auteur ancien, qui est probablement né et a grandi dans l'ancienne Cadix, aurait été parfaitement au courant des différents mécanismes de broyage du sud de l'Espagne.

Pourtant, à notre avis, placer ce moulin exclusivement dans le domaine de l'industrie de l'huile ne lui fait pas justice. Akerraz et Lenoir ont interprété à *Volubilis* une double fonction de ce moulin selon le type de roche. Le grès coquillier, avec les sillons de rhabillage allongés en « S » était utilisé pour broyer des olives, tandis que les moulins faits en basalte volcanique, dépourvus de sillons, mais très poreux, étaient destinés aux grains (Akerraz & Lenoir 2002: 203). J.-P. Brun soutenait également la nature « polyvalente » de ces moulins (Brun 1997b: 71-72).

Fig. 3.7: Reconstitution d'une scène de mouture domestique romaine dans le sud de l'Espagne (dessin T. Anderson.

Beaucoup reste encore à faire sur la question de la distinction entre les types de meules destinés aux différents secteurs d'activité (d'autres denrées alimentaires, les métaux, les pigments, le papier ...). Dans l'état actuel des recherches, à notre avis, il n'est pas possible d'établir la fonction de moulins cylindriques en se reposant uniquement sur des critères morphologiques, typologiques ou pétrographiques comme cela se fait à *Volubilis*. En dépit de la forte diffusion des pierres volcaniques, tous les types pétrographiques n'étaient pas disponibles de partout. En outre, les roches volcaniques très poreuses retrouvées sur d'autres sites sont parfois vêtues de sillons semblables à celles des presses à huile à *Volubilis,* alors que ce type de roche est réputée pour les céréales à *Volubilis*. C'est le cas, par exemple, pour l'une des deux *metae* en roche volcanique d'Oreto y Zuqueca (Ciudad Real).

D'après les données de l´état actuel des recherches, nous défendons l'aspect « multifonctionnel » de ces moulins avec les arguments suivant: 1) les moulins cylindriques sont, en fait, une version plus grande des meules rotatives manuelles qui avait été traditionnellement utilisées pour la mouture des grains depuis l'âge du Fer. Leur adoption dans l'industrie de l'huile à grande échelle n'a commencé qu'après la conquête romaine. Il n'est donc pas raisonnable que son utilisation principale (mouture de grains) avant son adoption par l'industrie de l'huile eu été complètement abandonnée, en particulier dans les régions riches de la production céréalière. 2) En raison de la rareté des moulins pompéiens et hydrauliques du sud de l'Espagne, le moulin cylindrique est le seul modèle qui pourrait s'adapter aux besoins « industriels » des boulangeries de *villae*, villes et villages. Nous voyons avec peine que cet rôle a été joué uniquement par des meules manuelles. 3) L'anneau-*catillus* du moulin cylindrique est très similaire d'un point de vue typologique au moulin romain de type Haltern-Rheingönheim, un modèle connu en Suisse à Avenches (en grès jaune), à Bâle (Bundsandstein), ainsi qu'à Saalburg (en roche volcanique) en Allemagne (Castella & Anderson 2004: 129-130; Hurbin 1982; Baatz 1995: 12, fig 12.). Ce moulin d'Europe centrale n'était évidemment pas destiné à broyer les olives, et, d'ailleurs, à Bâle il est associé à une boulangerie (Hurbin 1982). 4) Si les moulins cylindriques avaient été consacrés exclusivement à l'industrie de l'huile, ils seraient restés inactifs environ la moitié de l'année, en dehors de la durée de la récolte des olives, soit à partir de l'automne jusqu'à la fin de l'hiver. Contrairement aux céréales qui peuvent être stockées pendant de longues périodes, les olives devaient être traitées dans le plus bref délai après leur récolte (Pablo Casado et Nanen López, comm. pers.).

Fig. 3.16: Catillus en anneau (ring-mill) en roche volcanique de la ville romaine de Castulo (Jaén) (Photo musée Linares, inv pas CE01430_R.).

Il est donc plausible d'imaginer que certains moulins cylindriques aient été à certains moments de l'année employés pour la mouture des céréales et à d'autres moments pour le broyage des olives. Pour le passage d'une activité à une autre il serait question de nettoyer le moulin, et adapter de la lumière entre les pierres pour les besoins de chaque type de mouture.

Cela dit, la production des meules cylindriques était répandue dans notre zone d'étude. Les modèles volcaniques sont connus pour avoir été faits à la fois dans le Campo de Calatrava *Sisapo* (CR-1) et sur le site de Las Herrerias près de Bolaños (CR-2). À *Sisapo*, comme on le voit par les alvéoles circulaires creusées dans la roche, les meules ont été tirées directement à partir de masse rocheuse (MQ-2a). À Las Herrerias la technique d'extraction n'est pas connue parce que les anciens fronts de taille ont été détruits par les travaux d'extraction modernes

Moulins Pompéiens

La situation des moulins pompéiens a fait l'objet d'une étude récente que nous avons présentée au colloque de Lons-le-Saunier. En fait, ces moulins sont peu représentés dans l'*Hispania* romaine. La majorité de la douzaine connue a été importée des districts volcaniques situés ailleurs en Méditerranée. Au cours de deux années écoulées depuis le colloque de Lons-le-Saunier, plusieurs *catilli* ont fait surface, notamment à Empúries (Barcelone), Huesca (Aragon) et deux exemples supplémentaires à Pallaruelo de Monegros (Huesca) (recherche menée en collaboration avec L. Jaccottey). Tous sont apparemment en roches volcaniques à leucite provenant sans doute du district volcanique de Vulsini près d'Orvieto (Italie). Ces découvertes, en plus de celles qui vont certainement suivre, ne modifient pas l'hypothèse que la plupart des moulins présents sur le sol ibérique sont des importations de longue distance. Le seul exemple certifié d'un modèle pompéien produit sur le sol ibérique est un *catillus* inachevé en biocalcarenite, à *Baelo Claudia* (Cadix). Cette pièce, sans doute une copie locale d'un modèle volcanique, a probablement été produite au moyen d'un recyclage d'un élément d'architecture (MQ-1B).

Moulins hydrauliques romains

Le thème des moulins hydrauliques romains dans la péninsule ibérique mérite une grande quantité d'encre. Il est parfaitement raisonnable de supposer la présence de moulins à eau à travers le paysage de l'*Hispania* romaine, en particulier en tenant compte du grand nombre d'ouvrages hydrauliques. Citons par exemple le barrage de Proserpine près de Mérida, et les aqueducs qui sillonnaient le paysage, dont les meilleures représentations sont à Segovia et à Mérida. Ces derniers sont des exemples de la transmission rapide de la technologie dans d'autres parties du monde romain. Plus proches de la technologie du moulin à grain hydraulique étaient les nombreuses *norias*, grandes roues verticales en bois qui élevait l'eau dans les mines romaines de Rio Tinto à Huelva (Delgado & Regalado 2012). Cependant, il n'y a guère de traces de moulins hydrauliques eux-mêmes sur le terrain ou des meules caractéristiques dans les dépôts des musées, tels que ceux mis en lumière au cours des dernières années en France et en Suisse.

Le seul moulin hydraulique certifié dans la péninsule ibérique se trouve à *Conimbriga*, Portugal, où J.-P. Brun a reconnu des vestiges associés à une roue hydraulique verticale (Brun 1997a). Parmi les 55 meules du catalogue de *Conimbriga*, publié par Borges deux décennies avant la découverte de Brun, il y a seulement deux *metae* (en grès siliceux) (Borges 1978: 127, n ° 54-55), qui partageaient les caractéristiques des meules hydrauliques connues ailleurs. Ces éléments sont notamment es oeils perforés, l'angle de broyage et le léger rebord sur le pourtour de la *meta*. Le problème de d'interpréter ces pièces comme des meules hydrauliques est leur diamètre (48,4 et 47,3 cm), qui est inférieur aux plus petits modèles romains établis à 55 cm (Anderson *et al.* 2004: 6). En outre, l'absence de roches volcaniques dans la collection de *Conimbriga* et l'absence de logements d'anilles, des perforations ou de canaux pour « anilles-crampons », diminuent la possibilité qu'il s'agit de meules hydrauliques.

Un deuxième potentiel moulin hydraulique a été signalé par Philippe Leveau sur la villa romaine d'El Munts, Altafulla, à Tarragone (J.-P. Brun, comm. pers.). À partir de son expérience dans les meuneries de Barbegal, près d'Arles dans le sud de la France, Leveau est très bien placé pour identifier ce type d'installation. Nos enquêtes auprès des archéologues travaillant de la villa Munts n'ont cependant pas confirmé cette identification.

Plusieurs meules hydrauliques romaines sont, néanmoins, signalées dans la littérature archéologique de la péninsule ibérique. Trois sont identifiées par García Romero (2002: 623-624, fig 132-135) dans son étude sur l'exploitation minière romaine dans le sud de l'Espagne. Tous les trois, malheureusement, ne bénéficient pas de contextes certains, et bien que leurs diamètres soient compatibles avec les modèles romains, leur aspect en forme de disque rappelle davantage des meules médiévales.

Deux autres exemples sont signalées dans un article récent. L'un est en fait un *catillus* de moulin manuel de 34 cm de diamètre (Palomo & Fernández 2007: 517, fig 8). La nature du second est moins évidente. D'après les photos (Palomo & Fernández 2007: 514-515, fig. 6-7) et l'information orale de Silverio Gutiérrez, directeur du Musée de Villanueva de Córdoba, nous supposons que le moulin est en conglomérat et mesure environ 50 cm de diamètre. Sa meule tournante n'est pas typique, avec des bords incurvés et des logements carrés aux quatre points cardinaux, elle resemble des modèles cylindriques. Un cinquième logement en queue d'aronde est probablement une réparation. Sa *meta*, non visible sur la photo, a un œil d'environ 3 cm de diamètre qui est perforé de haut en bas. C'est la seule caractéristique que ce moulin partage avec des meules hydrauliques. S. Gutiérrez signale, néanmoins, que cette pièce a été découverte *in situ* dans un habitat sans source d'eau évidente. Par conséquent, à ce stade, il n'y a pas assez d'indices pour le certifier comme un moulin hydraulique.

Le seul exemple connu sur le sol ibérique qui partage les traits typologiques des meules de Barbegal (France) et d'Avenches (Suisse) est une *meta* à oeil percée mesurant 65 cm de diamètre (voir dessin au chap. 3) décorant l'entrée du site archéologique de Oreto y Zuqueca à Ciudad Real (Anderson *et al.* 2011: 161). Son lieu de découverte, à la périphérie de l'ancienne ville Antique d'*Oretum* et près de la rivière Jabalón, est une situation qui rappelle celle des moulins à eau découverts en dehors de la ville de Roman (Aventicum) en Suisse (Castella 1994). Sa matière, en roche volcanique, est sans doute une production locale ou régionale venant de l'un des nombreux affleurements volcaniques voisins du Campo de Calatrava. On ignore, cependant, si la production était dans une meulière d'extraction directe (MQ-2a) ou de détachement de blocs (MQ-2b).

Comme nous l'avons mentionné auparavant, il est très surprenant qu'aucun moulin hydraulique romaine n'ait été encore mis au jour, en particulier dans les centres de *Corduba* et d'*Emerita Augusta*, ou encore parmi les nombreux habitats romains fouillés ces dernières années dans le cadre de l'archéologie de sauvetage. Il faut néanmoins reconnaître que ces insallations sont très mal conservés et difficiles à identifier sur le terrain, comme J.-P. Brun l'a bien expliqué dans une récente présentation à Oxford (J.-P. Brun, comm. pers.). C'est peut-être juste une question de temps avant qu'ils ne commencent à apparaître parmi les découvertes archéologiques du sud de l'Espagne.

L'absence de meules romaines caractéristiques dans les dépôts des musées reste également un mystère. Nous avons déjà évoqué le problème de stockage qu'elles supposent et que par conséquent elles peuvent éventuellement rester sur le terrain après la fouille. Une autre explication de leur « absence » est que des modèles ibériques soient d'un type différent, qui n'ait rien à voir avec ceux identifiés au nord des Pyrénées. Dans ce cas, les exemples présentés par García Romero (2002) et Palomo et Fernández (2007) prennent un nouvel intérêt. Quoi qu'il en soit, il est évident qu'il y a encore beaucoup de recherches à mener sur ce sujet.

15.3.4. Moulins médiévaux

La période médiévale a héritée d'une large gamme de meules à la main, à traction animale et à eau de la tradition romaine. La nouveauté est l'introduction du moulin à vent.

Les meules manuelles ont perduré au Moyen Âge. Elles se distinguent des modèles des périodes précédentes par leur forme discoïdale, leur surface plate, leur manchon vertical logé dans un trou sur la surface supérieure, et un logement d'anille sur la surface inférieure. Les quelques meulières identifiées comme celles d'Arroyo de las Calzadillas (SE-1a) à Séville, Zagra (GR-5) à Grenade, Rambla Honda (AL-3) à Almería et Puerto de la Cadena (MU-1) à Murcia sont toutes de véritables meulières extractives (MQ-2a). Les deux premiers sites (GR-5 et SE-1a) ont produit exclusivement des meules manuelles standardisées, mesurant environ 50 cm de diamètre. Les meules manuelles correspondant à cette dimension sont conservées dans les dépôts des musées tout au long de notre zone d'étude. Des autres sites (AL-3, MU-1) ont produit, parmi d'autres extractions plus grandes, des modèles légèrement plus petits, d'environ 40 cm de diamètre.

Une impression différente est donnée par la publication de l'assemblage de meules manuelles du site de El Castillejo, Montefrío (Granada), datant du IXe au XIIe siècle (Motos Guirao 1987). Ici il y a une variété de modèles non standardisés mesurant entre 20 cm et 50 cm de diamètre, qui reflètent davantage des exploitations de surface (MQ-1a) plutôt que de véritables meulières d'extraction. Nous pouvons donc envisager pour les meules manuelles du Moyen Âge, à ce stade de la recherche, la coexistence de meulières exploitant des blocs de surface (MQ-1a) avec de meulières extractives (MQ-2), comme c'était le cas à l'époque romaine. Cependant, nous ne savons pas si la proportion de meulières de surface (MQ-1a) était faible comme au temps des Romains, ou si elle représentait une partie importante de la production.

Dans plusieurs meulières, ces modèles manuelles se trouvent côte à côte avec de plus grandes extractions destinées à des moulins à eau et à traction animale. Les *tahonas*, actionnés par des animaux, étaient, en fait, les héritiers naturels du moulin à sang romain et installés dans des zones sans accès à l'eau courante. La différence majeure, par rapport à l'époque romaine, est l'absence d'indice se rapportant au fait que ces moulins auraient été actionnés par l'homme. Cordóba de la Llave (1988: 839-840) signale des *tahonas* dans la province de Cordoue. Cependant, il note qu'aucun n'était connu dans la ville de Cordoue Ces moulins ont probablement joué un rôle mineur par rapport aux moulins à eau et aucune meulière ne leur peut être spécifiquement attribuée. Il est cependant probable qu'une partie des extractions directes de la masse rocheuse Rambla Honda (AL-3) et de Puerto de la Cadena (MU-1), sites se situant dans des régions très sèches, aurait été destinées à ces moulins à sang (*tahonas*). Nous ignorons toutefois si ces modèles sont équivalents en diamètre à ceux des moulins à eau.

Notre connaissance ces moulins est fondée sur un grand nombre de recherches molinologiques, notamment celles de Cordoue de la Llave (1988, 2003, 2011) à Cordoue, Reyes Mesa (2000, 2006) à Grenade, et Cara Barrionuevo (1999) dans les montagnes d'Alpujarra d'Almeria. Une référence très précoce est signalée dans un article récent citant un vieux récit islamique (Ajbar Maymu'a) signalant que le souverain Abul-Jattar, au cours de conflits internes en 743, s'est réfugié dans le moulin Kulayb sur le fleuve Guadalquivir (Palomo & Fernández 2007: 499). On sait peu de choses des meules qui équipaient ces premiers moulins et où elles ont été produites. Ces meules ne se trouvent pas dans les dépôts des musées et ne sont pas illustrées dans des publications archéologiques. Cette absence s'explique probablement (suivant le modèle proposé par J.-P. Brun pour les moulins hydrauliques romains) par le manque de fouilles des habitats du Moyen Âge et que le peu de travail de terrain a porté sur les secteurs urbains et non sur les périphéries où les moulins pourraient se situer.

D'après des recherches menées ailleurs, notamment en Suisse (Castella & Anderson 2004: 134-135), la tendance est pour ces grandes meules d'évoluer vers des formes plates. Quant aux aménagements, les oeils sont entièrement perforés et les logements d'anilles passent à la face inférieure de la meule tournante. L'absence de caractéristiques typologiques de ces meules ne fournit pas d'éléments de datation. Leurs diamètres se situent, également, dans la gamme de ceux des meules modernes et contemporaines, ce qui annule toute tentative de datation basée sur l'indicateur de diamètre.

Avec le nombre croissant de moulins durant la période médiévale, et surtout des moulins à eau, il y avait par conséquent une demande croissante de meules pour équiper les nouveaux moulins, mais aussi pour remplacer celles qui étaient usées. Suivant cette notion, et considérant le grand diamètre des meules, il est difficile d'imaginer des meulières qui n'exploitent pas la masse rocheuse (MQ-2), soit sous la forme de véritables meulières extractives (MQ-2a) ou de meulières de blocs (MQ-2b), ou encore d'exploitations de gros blocs de surface (MQ-1b). Cependant, étant donné que ces meules partagent des diamètres équivalents avec les périodes moderne et contemporaine, il est très difficile de les identifier sur le terrain.

Les grandes extractions qui partagent le même espace avec de petites extractions pour des meules manuelles sur des sites tels que Rambla Honda (AL-3) et Puerto de la Cadena (MU-1) peuvent probablement être datés de la période de domination islamique. L'absence de noms de lieux d'origine latine et l'abandon des roches volcaniques en faveur de conglomérats, suggèrent une datation médiévale. Il est également très probable que les meulières les plus récentes, de l'époque moderne et contemporaine, telles que celle de Moclín (GR-1a) et d'El Berrueco (CA-8), masquent en fait des phases antérieures médiévales.

La plupart des moulins à vent en Espagne se trouvent dans des zones qui étaient mal alimentées en eau. Dans la moitié sud du pays, il y a deux concentrations principales. La première se trouve dans La Mancha, rendu célèbre par les aventures de Don Quichotte, ou des ensembles peuvent être encore vus aujourd'hui avec leurs pales rectangulaires, fabriques avec des lattes de bois. La seconde concentration se trouve dans le sud-est, l'une des régions les plus sèches d'Espagne. Les pales de ces éoliennes sont des voiles triangulaires (Rojas & Amezcua-Ogayar 2005). En tout cas, il n'existe aucun indice que les techniques d'extraction de meules destinées aux moulins à vent étaient différentes de celles des autres moulins, donc les éoliens ont donc été fournis essentiellement par des meulières exploitant la roche-mère (MQ-2).

15.3.5. Moulins moderns et contemporains

Les moulins modernes et contemporains (fig. 3.28; fig. 3.30; fig. 3.23), bien que subissant quelques modifications techniques, sont pratiquement identiques au niveau de leurs meules, à ceux de la fin du Moyen Âge. Ces périodes sont l'apogée des meulières et correspondent à l'époque où les moulins étaient omniprésents dans le paysage. Comme indiqué dans un précédent chapitre, à l'époque du dictionnaire géographique Madoz (1845-1850), il y avait à travers le paysage de la péninsule ibérique, 22 492 moulins hydrauliques (à farine), 676 moulins à vent et 1476 *tahonas* (moulins à sang) (Lizarralde 2010). Il est évident que les moulins à eau, en particulier les *rodeznos* avec leurs roues horizontales, aient été de loin le type le plus dominant, dépassant allègrement les moulins à roue verticale (*aceña*), à vent et les *tahonas*. Reyes Mesa enregistre dans la province de Grenade, par exemple, seulement deux moulins à vent pour un total de 542 (Reyes Mesa 2006: 213). Des moulins manuels rotatifs dans ces temps sont relégués à la mouture du fourrage pour des animaux. Ils sont cependant inclus dans cette étude parce qu'ils ont aussi servi à moudre des denrées alimentaires pour la consommation humaine, en particulier dans les moments difficiles, comme pendant et après la guerre civile espagnole.

Dans ces périodes, la plupart des meulières exploitaient le socle rocheux (MQ-2). Le choix de la technique d'extraction directe produisant des alvéoles circulaires (MQ-2a) ou le détachement blocs (MQ-2b), dépendent de la nature de l'affleurement. Dans certaines exploitations

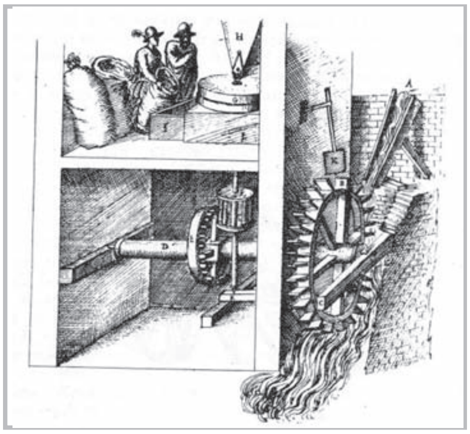


Fig. 3.28: Extrait du Codex of pseudo Juanele Turriano (c. 1595) représentant une aceña *(moulin à grain à roue verticale) (Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

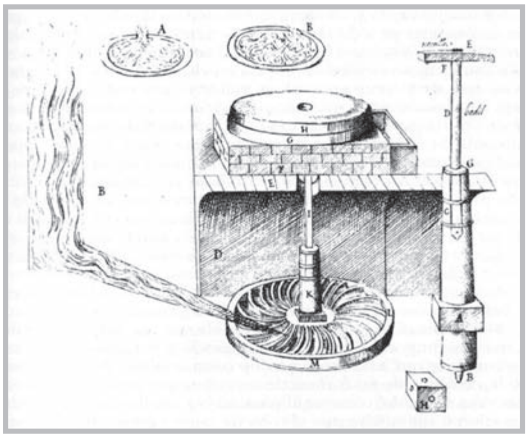


Fig. 3.30: Extrait du Codex of pseudo Juanele Turriano (c. 1595) représentant un rodezno *(moulin à grain à roue horizontale) (Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

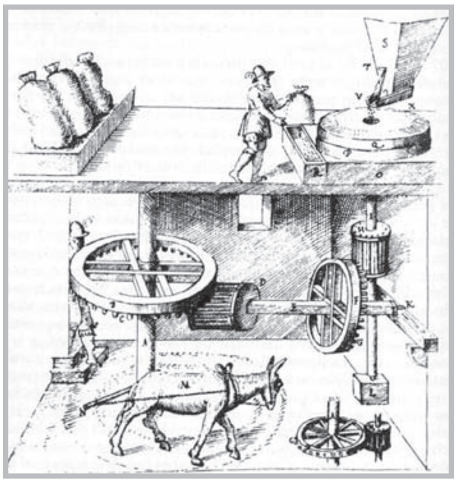


Fig. 3.23: Extrait du Codex of pseudo Juanele Turriano (c. 1595) représentant un tahona *(moulin à sang) (Archimedes Project, http://dmd.mpiwg-berlin.mpg.de/author/dmd/database/).*

plus grandes telles que Moclín (GR-1a) et Cabra, Cantera de los Frailes (CO-1), les meuliers ont taillée la roche directement (MQ-2a), laissant de nombreux fronts tubulaires couverts de traces diagonales. Dans d'autres cas, comme Alhama de Granada (GR-6) et Carcabuey, Cudillas (CO-3), les meules ont été tirées des blocs angulaires détachés auparavant par des leviers (MQ-2b).

Parallèlement aux grandes productions, il existait aussi des meulières plus discrètes avec un nombre très limité d'extractions. C'est le cas, par exemple de gros blocs de surface à Arbunuel (J-4) à Jaén, et à Molino de la Piedra (CO-5) près de Baena. Les extractions directes de ces grands blocs de surface (MQ-1b) étaient probablement destinées à des moulins voisins.

Enfin, les sources des meules rotatives qui servaient à broyer le fourrage n'ont pas été identifiées, ce qui conduit à penser qu'elles venaient de meulières où les blocs angulaires ont été détachés (MQ-2b) laissant peu de traces sur le terrain.

15.4. La géologie des meulières

Les fabricants de meules ont recherché des roches dures et abrasives qui étaient poreuses ou contenaient des inclusions ou des cristaux pour accroître l'abrasivité des pierres. Nous avons établi que les meuliers du sud de l'Espagne ont à travers le temps exploité neuf principaux types de roches. Certains d'entre eux ont été préférés durant des périodes chronologiques spécifiques, tandis que d'autres ont été exploitées pendant de plus longues périodes.

La plupart des identifications de ces roches ont été réalisées à l'échelle macroscopique. Les seules analyses géochimiques que nous avons effectuées ont été prises en charge par le Norwegian Geological Survey (NGU) à Trondheim, en Norvège. Ces analyses ont été effectuées sur des échantillons volcaniques du Cabo de Gata, dans le district volcanique du sud-est (SE Spanish Volcanic Province), ainsi que sur des échantillons de la région volcanique Campo de Calatrava (Calatrava Volcanic Province) et sont publiées dans un article récent (Anderson *et al.* 2011: 157). Une dizaine d'autres analyses sont actuellement en cours par Jane H. Scarrow et Aitor Cambeses du département de géologie de l'Université de Grenade sur de meules volcaniques déposées dans le musée de Murcia. Ces dernières,confirmant l'exploitation de lamproites et citées à plusieurs reprises dans ce travail, n'ont pas encore été complétées. Ce qui suit est une liste des principaux types de roches meulières identifiées dans notre zone d'étude:

15.4.1. Roches sédimentaires

En règle générale, un certain nombre de roches sédimentaires ont été exploitées dans l'ensemble du sud de l'Espagne. Certains types ont été plus prisés que d'autres. Ils peuvent être globalement separés en roches grossières et des roches fines.

Parmi les roches grossières sont les biocalcarenites jaunâtres poreuses (*ostionera*), riches en coquilles, exploitées depuis la Préhistoire (meules de à va-et-vient) jusqu'au XXe siècle dans des carrières le long de la Baie de Cadix sur la côte atlantique. Depuis l'époque romaine, cette pierre a été également très prisée pour les matériaux de construction.

Les conglomérats (puddings) brunâtres à galets ont été largement exploités pour des meules. La plupart des affleurements se trouvent dans la chaîne Bétique, au sud du bassin du Guadalquivir. La taille des cailloux dans la matrice peut varier d'entre 2 cm jusqu'à 10 cm. Cette roche ne semble pas avoir été appréciée à l'époque romaine. Son exploitation est en revanche devenue courante au Moyen Âge et a perduré jusqu'à l'époque contemporaine.

Des tufs calcaires très poreux, couleur crème, appelés communément « travertins », ont été sollicités pour les meules manuelles et les meules à sang durant l'âge du Fer et, dans une moindre mesure, à l'époque romaine. Dans la province de Guadalajara, au nord, il y a une concentration d'exploitations datant d'époque contemporaine. En fait, le nom du hameau de Tobes (GUA-5), un producteur de meules, provient du nom de la roche (*toba*).

Parmi les pierres sédimentaires plus fines recherchées pour les meules sont les calcaires blancs, des dolomites blanches (parfois grisâtres) et le *rosso ammonitico* (de couleur rose). Ces affleurements, situés pour la plupart au sud du bassin du fleuve Guadalquivir, ont été vraisemblablement exploités à partir de la fin du Moyen Âge jusqu'au IXXe siècle. Les exploitations les plus renommées sont celles d'El Berrrueco (CA-8), de Moclín (GR-1), d'El Torcal (MA-1) et de Cabra, Córdoba (CO-1). Ces pierres nécessitent un rhabillage constant et ont été probablement appréciées, car elles livrent une farine blanche.

15.4.2. Roches métamorphiques

La seule roche métamorphique identifiée dans notre étude est le schiste. Les micaschistes munis de cristaux de grenat dépassaient des surfaces de broyage et favorisaient l'abrasivité de la meule. Cette pierre a été très appréciée pour les meules à va-et-vient dans des contextes pré- et protohistoriques. Elles ont probablement été recueillies dans des exploitations de surface (MQ-1a). La seule meulière de schiste moderne fabriquant de grandes meules cylindriques dans notre zone d'étude est à El Campillo dans la province de Huelva (HU-1). La faible exploitation du schiste dans des temps récents contraste avec les exploitations massives de ce rocher en Norvège lors du Moyen Âge dans des meulières de schiste à grenat d'Hyllestad, et plus tard, de schiste à staurolite à Selbu (Grenne *et al.* 2008).

15.4.3. Roches ignées

Le premier groupe de roches ignées est représenté par une variété de granitoïdes, roches cristallines, très dures. Le terme « *rocas berroqueñas* » pour cette roche a souvent été utilisées dans de toponymes. Dans notre zone d'étude, les affleurements granitiques sont circonscrits dans une vaste zone au nord du bassin du fleuve Guadalquivir, depuis la province d'Estrémadure à la province de Jaén. Dans certaines régions, des agents naturels ont sculpté des rochers en leur donnant de formes arrondies, faciles à détacher du socle, et se prêtent à la fabrication des meules. Des variantes de granites ont été exploitées de façon continue depuis la préhistoire pour des meules à va-et-vient et jusqu'au IXXe (ou XXe) siècle pour les grandes meules hydrauliques.

Un deuxième groupe de roches ignées comprend des roches volcaniques vésiculaires noires, grises et rougeâtres. Dans le sud de la péninsule ibérique, ces roches proviennent spécifiquement de deux districts volcaniques: 1) le district volcanique espagnol du Sud-Est, réparti à travers les provinces d'Almeria, de Murcie et une partie d'Albacete et 2) le district de Campo de Calatrava dans la province de Ciudad Real dans le centre de notre zone d'étude. Bien qu'il soit possible de les identifier avec un œil exercé, établir des portraits précis de ces roches (rhyolites, dacites, basaltes, lamproïtes, melelinites) nécessite des analyses pétrographiques et géochimiques.

Il existe des indices que des roches volcanique ont été exploitées depuis la fin de la Préhistoire. Cependant, c'est à partir de l'époque romaine qu'elles ont connue leur plus grande utilisation pour la fabrication de moulins manuels rotatifs et de moulins à sang. Ceux-ci ont ensuite parfois parcouru de très longues distances.

Pour conclure ce chapitre, il est intéressant de noter qu'aucune exploitation de roche siliceuse, dure et poreuse, comparable à la roche meulière exploitée à grande échelle dans le bassin parisien (par exemple à La Ferté-sous-Jouarre) n'a été identifiée dans la péninsule ibérique. Le plus proche rival ibérique à la pierre dite « meulière » française était le grès de Montjuïc de Barcelone, une carrière qui a exporté des meules du nord au sud de la Méditerranée et même au-delà.

15.5. Meulières: terminologie, la topographie, les techniques

La terminologie que nous avons employée pour décrire les techniques d'extraction de meulières est empruntée en partie à celles des carrières de pierre de taille (fig. 5.1). La recherche de J.-C. Bessac (1996, 2003) portant sur les outils, les « gestes » et les sites d'extraction, est omniprésente tout au long de cette étude. Quelques définitions telles que « percussion lancée » et « percussion posée » (traduits maladroitement en anglais comme « *direct* » et « *indirect percussion* ») proviennent des définitions établies par Bessac.

Pour la terminologie anglaise plus précise des meulières, nous avons emprunté des termes à Crawford (1955), Runnels (1981), Tucker (1985), Peacock (1986, 1987) et Jobey (1986). La terminologie anglaise est aussi fortement influencée par les publications françaises de A. Belmont (2006; 2011a; 2011b) et du Groupe Meule (Buchsenschutz *et al.* 2011). Par exemple, le terme « tube » ou « tubulaire », présent tout au long de ce travail en référence au creux d'extraction circulaire multiple, est une traduction directe de l'apparenté français. Pour les termes en espagnol nous nous sommes appuyés sur les communications personnelles et les publications de Pilar Pascual et Pedro García (Pascual & García 2011) dans La Rioja (et ses environs) et Joaquín Sánchez à Minorque (Sánchez 2011). La recherche récente de Maestro Hernández (2011) par rapport à la fabrication de meules dans les montagnes de Palencia, a également fourni des termes utiles. En raison de l'intérêt international croissant pour les meules, moulins et meulières, un glossaire multilingue, développé déjà en partie par F. Jodry du Groupe Meule (Jodry 2011), est un projet vital pour l'avenir.

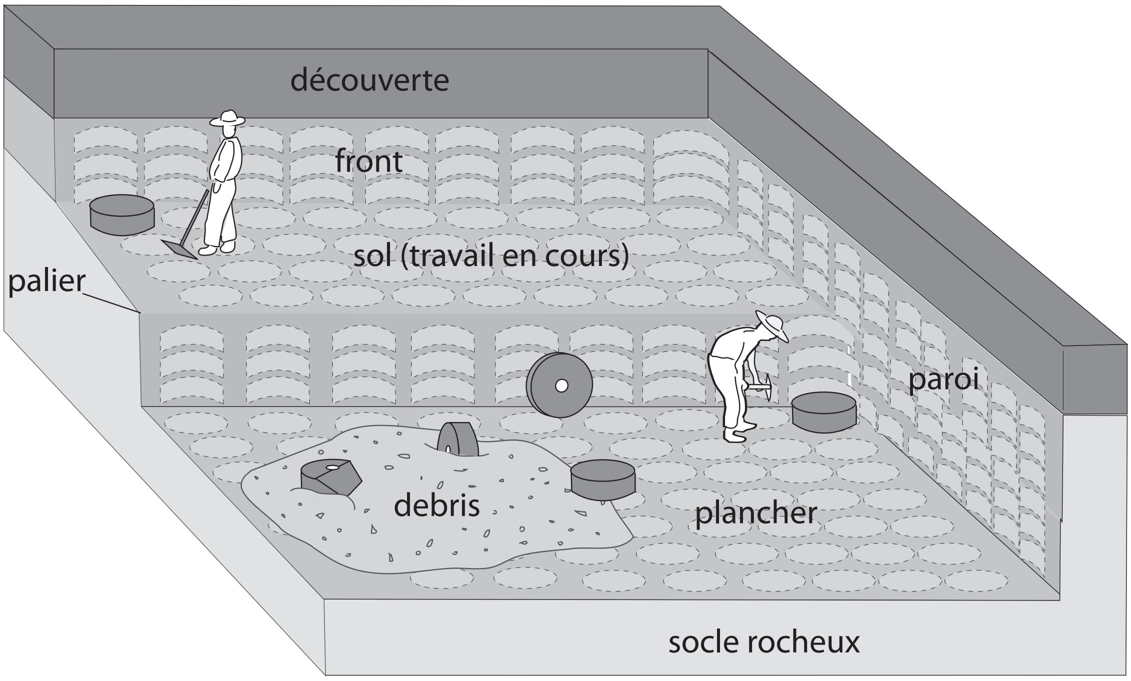


Fig. 5.1: Schéma illustrant la terminologie des meulières (dessin T. Anderson).

15.5.1. La topographie des meulières

Dans ce secteur, nous avons défini les caractéristiques topographiques où les meulières se situent le plus souvent (fig. 5.2). Celles-ci sont les suivantes: a) meulière de pente; b) meulière de falaise ou escarpement ; c) meulière de fond de ravin ou lit de la rivière; d) meulière en bord de vallée ou de ravin; e) meulière de plateau; f) meulière de littoral. Tous ces éléments topographiques coïncident avec des emplacements où le socle rocheux est exposé à la surface (ou très près de la surface) ou encore des endroits qui se prêtent à l'accumulation de blocs de surface, dans la plupart des cas par des processus naturels. La classification et la morphologie des meulières, développée plus tard dans le chapitre 6, dépendent en partie de leur emplacement topographique. Nous avons cependant retenu cette description dans ce chapitre afin de ne pas multiplier les variables qui ont servi à établir une classification des meulières (voir chapitre 6).

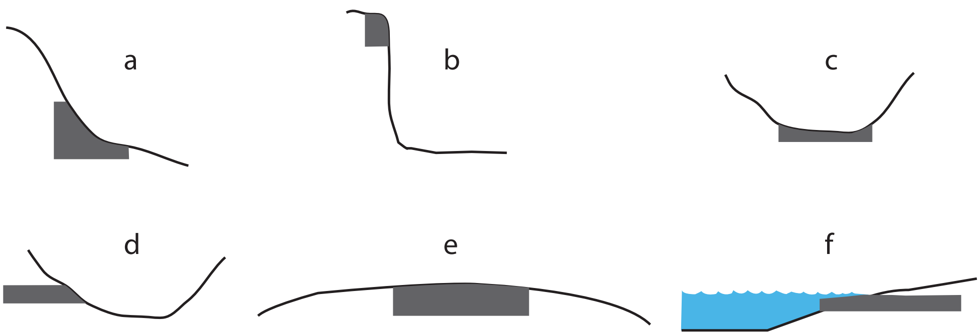


Fig. 5.2: Section schématique de la topographie des meulières exploitant le substratum rocheux: a) en pente; b) falaise ou d'escarpement; c) lit de la rivière ou ravin; d) bord de vallée ou ravin; e) haut de plateau; f) littoral (dessin T. Anderson).

15.5.2. Des outils et des techniques de production

Quant à la description des outils du meulier, nous nous sommes limités à l'interprétation des traces visibles sur les fronts de taille les meulières que nous avons visitées, ainsi qu'aux informations provenant des photographies de meuliers dans les montagnes de Palencia et à Montjuïc de Barcelone (notamment les travaux du pic et du levier). Il faut se rappeler que les traces d'outils, tels que nous les voyons aujourd'hui, sont généralement trop mal conservées pour permettre des analyses fines. Des études sérieuses de traceologie ne peuvent être entreprises que dans le cadre de fouilles archéologiques modernes où les traces, où les marques d'outils sont bien conservées sous les débris des travaux. Par conséquent, les techniques présentées dans ce chapitre sont basées principalement sur les travaux de Bessac (1996), et fortement influencées par les observations personnelles lors des fouilles à Châbles en Suisse (Anderson *et al.* 2003), ainsi que lors des fouilles de meulières en France à Claix (Charente) et au Mont Vouan (Haute-Savoie) (sous la direction d'A. Belmont).

Partant du point de vue « qu'une image vaut mille mots », nous avons tenté de reconstituer les différentes techniques au moyen de dessins (fig. 5.7; fig. 5.20; 5.62). Chaque technique est en fonction de la roche, notamment si elle était naturellement compacte et homogène ou si elle comprenait des fissures naturelles qui ont servi pour l'extraction des blocs. En général, le pic a été employé pour couper des tranchées dans la roche massive, alors qu'un levier ou un pied de biche a été utilisé pour détacher des blocs lors que la roche présentait des fissures naturelles.

Les techniques de façonnage de meules, la phase de travail après l'extraction, variaient selon le type de produit voulu et le type de roche (fig. 5.44). Dans ce chapitre, nous avons exploré la « chaîne opératoire » du façonnage selon que la source était 1) petit bloc de surface, 2) un bloc anguleux détaché, ou 3) un cylindre provenant d'une meulière à extraction directe (*true extractive quarry*).

Dans chapitre 5, nous avons décrit également brièvement la production de meules composites, c'est-à-dire des meules (non-monolithes) assemblées en segments, avec du plâtre, et liés autour de leur circonférence avec des bandes de fer. Les meulières de ces types de meules, certifiées par un certain nombre de sources historiques, comme les meulières de blocs, sont difficiles à identifier sur le terrain parce qu'elles ne laissent pas des fronts de taille caractéristiques et parce que leur assemblage se réalise ailleurs, probablement dans une forge en raison du cerclage de bandes en fer.

Selon des travaux expérimentaux entrepris en Suisse (Anderson *et al.* 2003: 47), nous proposons qu'en moyenne, un moulin à bras rotatif (y compris les pierres), depuis l'extraction au façonnage, prenne entre deux à trois jours de travail à fabriquer. En revanche, une seule meule plus grande prend plus de temps, entre trois à sept jours, comme indiqué par Maestro Hernández pour décrire les travaux du XXe siècle à Palencia (2011). D'après les informations fournies par Madoz concernant la production annuelle à El Berrueco (CA-8) (Madoz 1846, Vol. 4: 290), nous arrivons à un chiffre de deux meules par semaine avec une équipe de quatre à cinq travailleurs. Ces approximations, bien sûr, varient en fonction de la dureté de la roche et de l'habileté des meuliers.

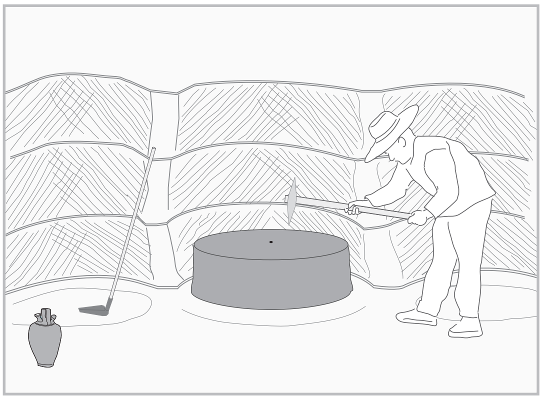


Fig. 5.7: Reconstruction de la technique d'extraction directe au pic d'une grande meule. Cette technique produit des alvéoles et des multiples traces diagonales sur le front (dessin T. Anderson).

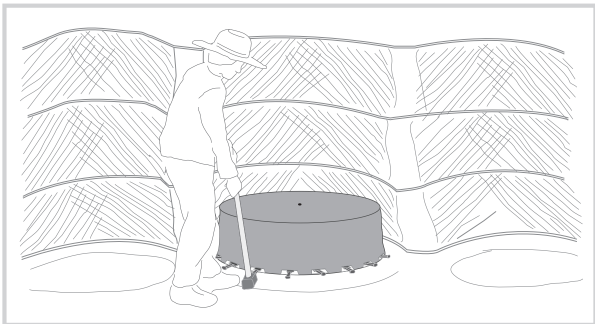


Fig. 5.20: Reconstruction de la technique de détachement d'une meule au moyen de coins en fer (dessin T. Anderson).

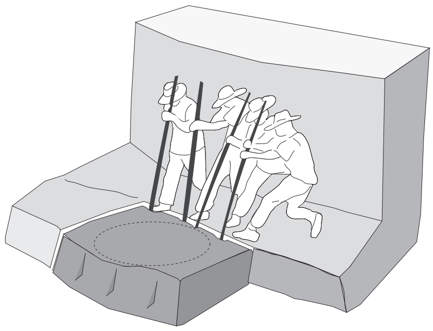


Fig. 5.26: Reconstruction de la technique de détachement d'un bloc angulaire (dessin T. Anderson basé sur une photographie de http://burgess-shale.rom.on.ca/en/transcripts/slideshow_1998.html).

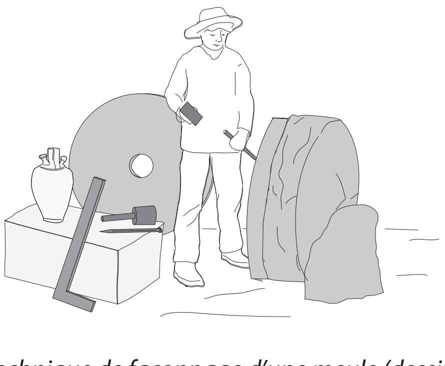


Fig. 5.44: Reconstruction de la technique de façonnage d'une meule (dessin T. Anderson).

15.6. La classification de meulières

La route menant au système de classification des meulières (MQ = *millstone quarry*) dans le chapitre 6, compte tenu de sa simplicité, a été extrêmement complexe. Pour le classement des sites du sud de l'Espagne, nous avons d'abord tenté d'inclure toutes les variables, c'est-à-dire la topographie, les techniques d'extraction et la morphologie des sites, ainsi que les observations faites sur d'autres sites en France, en Suisse et en Allemagne. Après une série d'examens, nous sommes arrivés à la conclusion qu'une classification comprenant toutes ces variables conduisait vers une typologie incongrue comprenant presque autant de catégories que de meulières.

Nous avons donc opté pour une classification extrêmement simple ancrée sur la nature de la roche (fig. 6.1). Par conséquent, des meulières exploitant des blocs de surface sont étiquetées avec le numéro 1 (MQ-1), et celles qui exploitaient le socle rocheux sont étiquetées 2 (MQ-2). Chacune de ces catégories générales est ensuite subdivisée en deux.

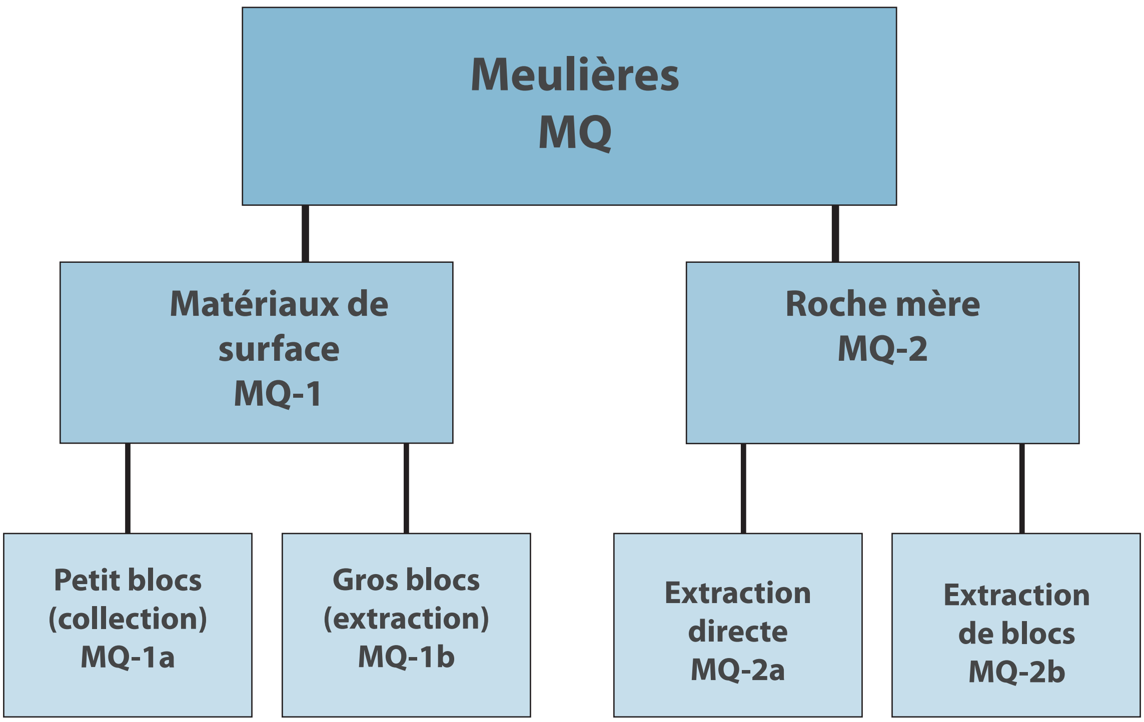


Fig. 6.1: Organigramme de la classification des meulières identifiées dans le sud de l'Espagne.

15.6.1. Blocs de surface (MQ-1)

Collection de petits blocs de surface (MQ-1a)

Des meulières exploitant de blocs de surface sont des sites associés à des emplacements topographiques spécifiques tels que des lits de rivières, des ravins, des talus, des éboulis et des moraines (fig. 6.2). Elles comprennent des accumulations de roches avec des propriétés de mouture appropriées et qui pourraient être collectées à plusieurs reprises sans difficulté comme matériaux de surface, sans avoir besoin de creuser le sol. Ces blocs ont été généralement sculptés par des processus naturels dans une forme proche de celle d'un moulin à bras. Le terme « à plusieurs reprises » est à souligner, car un petit bloc isolé ramassé de manière aléatoire ne constitue pas une meulière. Bien que ce genre de sites étaient sans doute nombreux, ils sont impossibles d'identifier sur le terrain parce qu'ils n'ont laissé aucune trace perceptible.

Même s'ils ne sont pas identifiés sur le terrain, ces sites peuvent être déduits à partir de la forme générale des meules et de l'observation de la patine des surfaces des meules à va-et-vient et des meules rotatives. Les va-et-vient présentent des bases arrondies et les meules rotatives des sections hémisphériques ce qui donne à penser , en raison de leur forme, qu'ils étaient fabriqués à partir de blocs roulés. Ceci est confirmé lorsqu'une différence de texture de surface peut être observée entre les surfaces originales brutes (le cortex original) résultant de processus naturels et les surfaces taillées et bouchardées (Anderson & Castella 2007: 153).

D'après la grande quantité de meules à va-et-vient de la Préhistoire, de l'âge du Bronze et de la première moitié de l'âge du Fer dans les collections des musées, il est raisonnable de supposer que ces meulières étaient omniprésentes dans le paysage du sud de l'Espagne. Pour la plupart, elles étaient sans doute établies près des habitats, afin de réduire le temps et les efforts liés au transport.

Leur pétrographie est variée et dépend de l'environnement géologique de l'habitat. Dans la moitié orientale de notre zone d'étude, des micas schistes, des grès et des conglomérats sont dominants (Delgado Raack 2008: 138). Dans les districts volcaniques de la province d'Almería, des dacites et des rhyolites auraient été disponibles en tant que matériaux de surface. Dans les

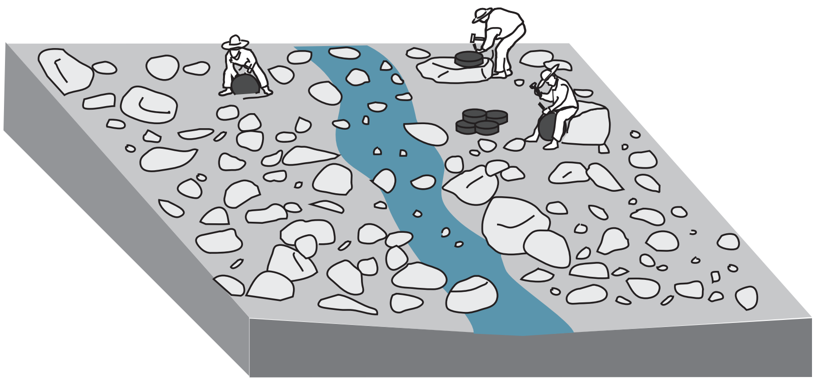


Fig. 6.2: Reconstitution schématique du ramassage de petits blocs de surface (MQ-1a) (dessin T. Anderson).

régions de l'ouest de notre zone d'étude, les granits étaient probablement la roche de surface dominante, comme on le voit à travers les meules à va-et-vient du site de l'âge du Fer de Cancho Roano (Huelva).

Pour les plus récentes phases de l'âge du Fer et de l'époque romaine, aucun site de ce type n'a été documenté dans notre zone d'étude. Bien que les meulières d'extraction ont commencé progressivement à dominer la production de meules, surtout à l'époque romaine, des matériaux de surface ont continué à être exploités comme alternative locale à l'importation de produits exogènes. Dans La Rioja, près d'une villa romaine, il y a des indices de ramassage de blocs de surface pour des meules depuis les dépôts alluviaux (Pascual & García 2010: 287-288). En Suisse romaine, des granites, des schistes, des gneiss et des verrucanos ont été exploités comme des blocs de surface et ont servi comme alternatives locales à des meules taillées dans des meulières de brèche rouge, grès coquillier, et *Bundsandstein* (Anderson *et al.* 2003: 64-67). En Norvège, dans ces périodes précoces, la production de blocs erratiques semble avoir été la norme, plus nombreuse que les meulières extractives (Dahlin & Anderson, sous presse). L'omniprésence de gneiss, de granites et de schistes en forme de blocs erratiques, ont peut-être même freiné l'émergence de meulières extractives du mica schiste à Hyllestad apparues qu'au VIIIe siècle (Grenne *et al.* 2008: 48, 64).

Les exploitations de blocs de surface, bien que maintenant invisible à l'œil de l'archéologue, étaient la meulière par excellence de la Préhistoire et de la Protohistoire. Bien qu'elles continuent d'exister dans les périodes ultérieures, leur production était proportionnellement faible par rapport à celle des meulières d'extraction. En termes techniques, ces travaux ne demandaient que la connaissance du façonnage des meules au moyen du débitage et du bourchardage et, dans le cas des certaines meules rotatives, la connaissance de la technique pour scinder un bloc en deux parties égales. Plus important encore, ces exploitations n'ont pas demandé au meulier le même savoir-faire et les mêmes outils de meulières où les meules ont été extraites du substratum rocheux.

Extraction depuis des gros blocs de surface (MQ-1b)

La deuxième catégorie de meulière est une variante de celle de collecte de blocs de surface (fig. 6.4; 6.6, 6.8; 6.10). Elle s'en distingue, car les blocs exploités étaient beaucoup plus grands et par conséquent, ils ont servi de meulières d'extraction directe. Ce type de travaux requièrent le savoir-faire et l'outillage des meulières extractives directes.

Cette catégorie a été divisée en quatre groupes (MQ-1b-1-4). Les deux premiers (MQ-1b-1-2) sont semblables et correspondent à de grands blocs déplacés par des processus naturels. MQ-1B-1 correspond à des talus comprenant un grand nombre de gros blocs qui ont servi pour la fabrication multiple de meules. Des exemples sont sur les sites de Perdrizas près Moclín, Granada (GR-1b), Castillo de Locubín, Jaén (J-1) et Vélez de Benaudalla, Granada (GR-10). Dans le cas de la seconde, MQ-1b-2, la source se compose d'un grand bloc isolé (le produit, par exemple, d'un glissement de terrain), comme c'est le cas à Arbuniel, Jaén (J-4) et Molino de la Piedra, Córdoba (CO-5). Cette deuxième catégorie pourrait également inclure des gros blocs erratiques, une source de meules connue ailleurs, mais qui n'a pas été identifiée dans notre zone d'étude. Bien que les techniques d'extraction soient identiques avec MQ-1b-1, le volume de production d'une catégorie de site à l'autre est très différent. C'est la raison pour laquelle les exploitations de talus (MQ-1b-1) sont potentiellement beaucoup plus grandes que les productions de blocs simples (MQ-1b-2).

La troisième catégorie, MQ-1b-3, est celle de grandes dalles et blocs de surface trouvés dans certaines unités géologiques particulières. La différence avec la catégorie précédente, est qu'ils n'ont pas été transportés par les glissements de terrain, des torrents ou les glaciers, mais engendrés *in situ* après des millions d'années par l'intermédiaire d'agents d'érosion. Les meilleurs exemples sont les sites de El Torcal (MA-1), Teba (MA-2) et Fuensanta, Loja (GR-2) dans les formations karstiques. Cette catégorie comprend également des grands blocs de granite arrondis, dits *bolos* ou *piedras caballeras*, également formés *in situ* par un agent d'érosion dans des unités de granite.

La quatrième (MQ-1b-4) est celle des blocs destinés à l'origine à l'architecture qui ont été recyclés en meules. Un exemple concret est une meule pompéienne inachevée dans la ville romaine de *Baelo Claudia* tirée d'une pierre de taille ou tambour de colonne en bio-calcarénite. Un autre exemple est l'utilisation présumée de segments de tambour de la carrière romaine de Cerro Bellido (SE-4) pour fabriquer des meules au Moyen Âge.

Il est difficile de quantifier ces productions. Les cas de MQ-1b-1 sont généralement des productions alternatives associés à une meulière extractive proche, comme c'est le cas de grands blocs d'éboulis de Las Pedrizas (GR-1b), à moins d'un kilomètre de la grande meulière extractive de Moclín (GR-1a). Les deux exemples d'exploitation de grands blocs isolés (MQ-1b-2) semblent être des productions locales très proches ou immédiatement à côté de moulins à eau. Ces extractions ont peut-être été un moyen provisoire pour remplacer une meule cassée en attendant un remplacement permanent. Ces productions ont pu également être destinées à des tâches plus ingrates telles que le broyage des fourrages. La catégorie MQ-1b-3, en raison de la quantité illimitée de matière première, pourrait renvoyée à de grandes productions et atteindre les larges sphères de la distribution. C'est vraisemblablement le cas des sites d'El Torcal, Málaga (MA-1) et Loja, Grenade (GR-2/3). La catégorie MQ-1B-4, recyclant des éléments d'architecture, est presque « anecdotique » et mal représentée dans notre zone d'étude.

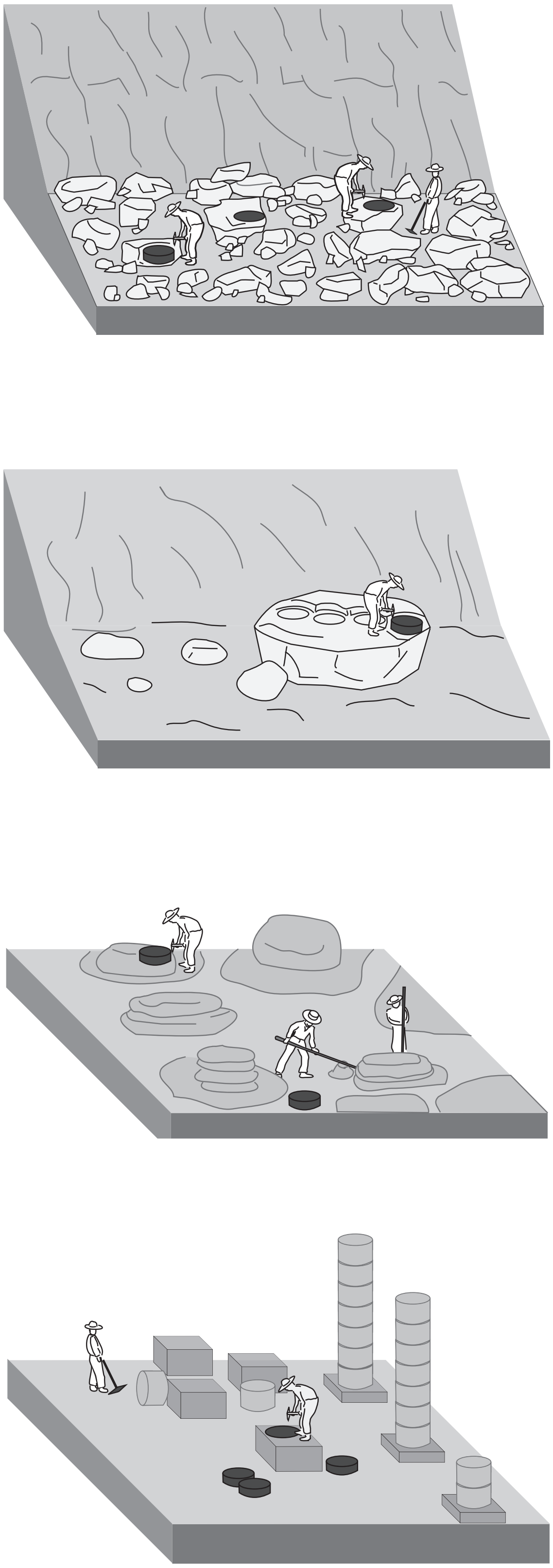


Fig. 6.4; 6.6; 6.8; 6.10: Reconstitution schématique des meulières à extraction directe MQ-1B à partir des gros blocs. MQ-1b1: talus; MQ-1b2: gros bloc unique ("erratique"); MQ-1B3: blocs dans champs karstiques ou granitiques; MQ-1B-4: matériaux de construction recyclés (dessins T. Anderson).

15.6. Exploitations de la roche mère (MQ-2)

La deuxième grande catégorie de meulières, ce sont les sites qui exploitent le socle massif (MQ-2). Ces sites diffèrent des exploitations de blocs de surface, car ils requièrent un processus d'extraction qui implique un degré élevé de savoir-faire, ainsi qu'une panoplie d'outils qui nécessitent un entretien et réparation constante. Dans ces cas, on peut parler de véritables fabricants de meules « professionnels », ou *moleros* comme on les appelle en espagnol. Ces sites représentent la façon la plus économique d'exploiter la roche et permettent d'exploiter des affleurements massifs d'une manière intensive à travers une longue période de temps. Ils se subdivisent en deux grandes catégories, en fonction du procédé d'extraction. Dans les meulières d'extraction directe (MQ-2a) les meuliers ont extrait les meules directement de la masse rocheuse laissant des traces circulaires sur les fronts de taille. Dans les meulières de blocs (MQ-2b), en revanche, les travailleurs ont détaché des blocs angulaires au moyen de leviers, laissant des fronts de taille beaucoup plus difficiles à identifier sur le terrain.

15.6.1. Meulières d'extraction directe (MQ-2a)

De « véritables » meulières extractives (« true extractive quarries »), terme emprunté à Runnels 1981: 72), sont des sites où les meules ont été extraites directement du socle rocheux massif (fig. 6.12; 6.15). Ces exploitations laissent des traces circulaires caractéristiques, dites des alvéoles, sur les fronts de taille. Ces productions nécessitent une utilisation habile du pic, l'outil qu'au moyen de la technique de percussion lancée, produit la tranchée annulaire autour du cylindre. Les sites typiques de ce genre présentent des fronts tubulaires, soit le résultat d'extractions horizontales multiples, superposées, et couvertes des traces diagonales du pic. Les planchers de ces meulières, quand ils sont conservés et visibles, portent de marques de détachement du cylindre. Ces marques se différencient selon la technique employée: marques des emboitures ou encoignures pour des coins, marques de ciseaux ou des marques de la pointe du pic.

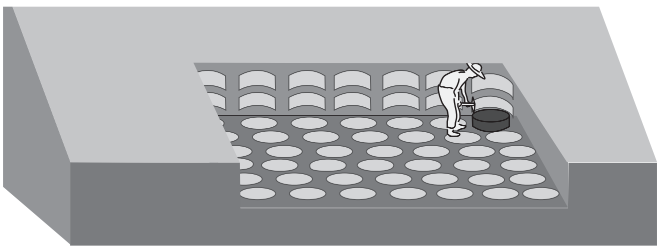


Fig. 6.12: Reconstitution schématique d'une carrière de meules à extraction directe (MQ-2a) où les extractions horizontales superposées laissent des fronts en forme de tubes (dessin T. Anderson).

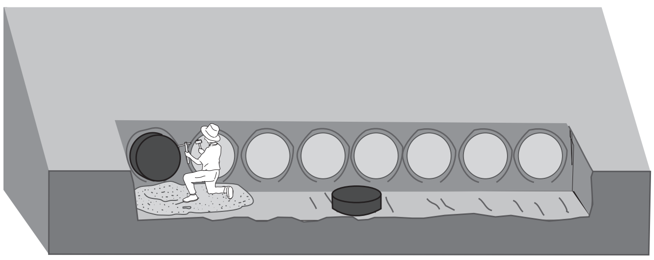


Fig. 6.15: Reconstitution schématique d'une carrière de meules à extraction directe suivant des plans verticaux (MQ-2a2) (dessin T. Anderson).

15.6.2. Meulières d'extraction de blocs (MQ-2b)

Les meulières extractives dites de blocs se différencient des précédentes en raison d'une extraction de blocs profitant des fissures naturelles (fig. 6.17). Par conséquent, les blocs détachés ne sont pas cylindriques, mais de forme angulaire. Le principal outil d'extraction de ces sites n'est pas le pic, mais le levier ou le pied de biche. Dans ce cas, la roche n'est pas massive et homogène, Les fronts de taille de ces meulières ne révèlent pas que des extractions anthropiques ont eu lieu. Ces extractions peuvent, en effet, être prises pour des procédés mécaniques naturels tels que la gélifraction. Comme ils sont difficiles à identifier sur le terrain, c'est généralement la présence de cylindres inachevés abandonnés qui trahissent leur existence.

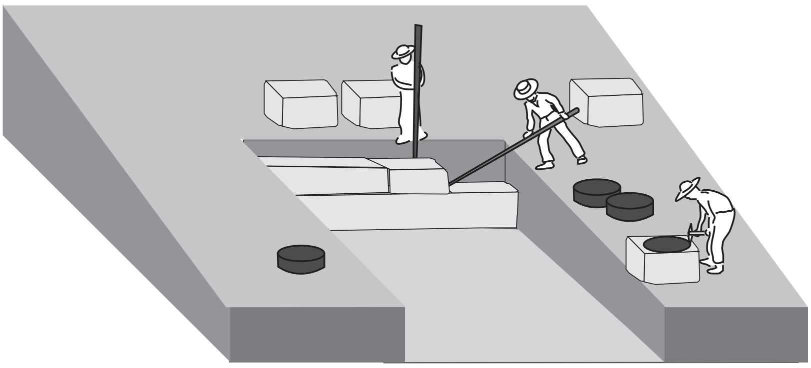


Fig. 6.17: Reconstitution schématique d'une carrière de meules MQ-2b1 où des blocs angulaires ont été détachés le long de plans horizontaux (dessin T. Anderson).

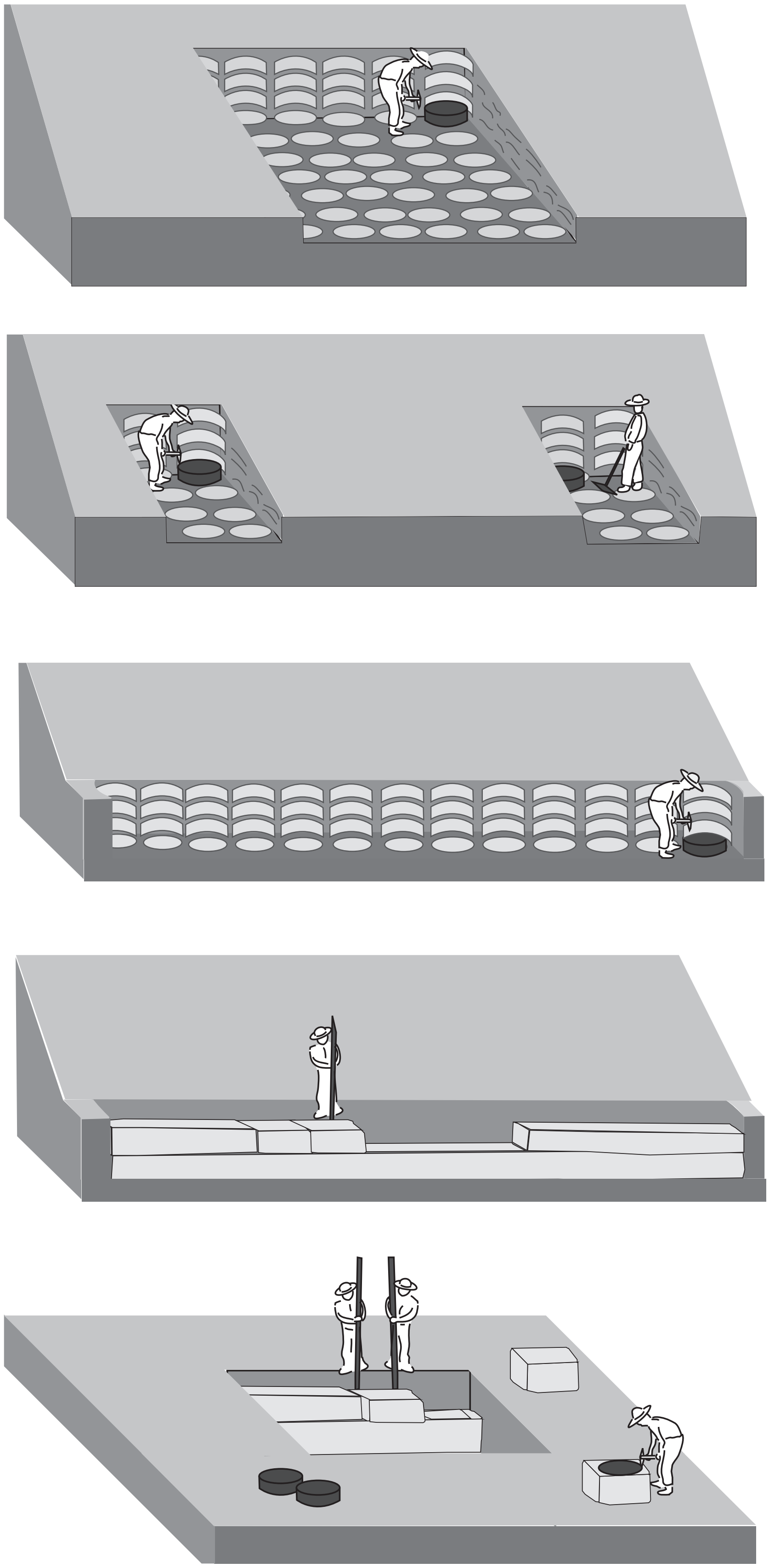
15.7. La morphologie des meulières extractives

Les définitions de la morphologie des meulières extractives (fig. 6.20; 6.23; 6.25; 6.26; 6.28; 6.30; 6.32; 6.34; 6.36) se basent en partie sur des termes empruntés au vocabulaire des carrières de construction (pierre de taille). Les termes « en palier » (bench quarry), « en fosse » (pit quarry), « en tranchée » (trench quarry), « de bordure (edge quarry) » et « en poche » (pocket quarry) correspondent à des exploitations en plein air. La définition de meulière « en poche », dans notre étude s'associe à de petites exploitations multiples situées sur les pentes. Les noms des deux autres types d'exploitations « meulières extentives peu profondes contigües » et « meulières extensives dispersées », termes inspirés de l'œuvre de J.-C. Bessac (2003), sont moins fréquents dans le domaine de la construction, mais se prêtent bien à une série d'exploitations extensives en plein air (fig. 6.39). Les carrières souterraines, communes dans le sud de l'Espagne pour la pierre de taille, ne sont représentées dans notre zone d'étude que par un seul exemple. Tous ces termes sont tous liés aux caractéristiques de l'affleurement, ses dimensions, son accessibilité, son inclinaison et profondeur, la direction de la progression du travail, et si les extractions étaient contiguës ou separées.

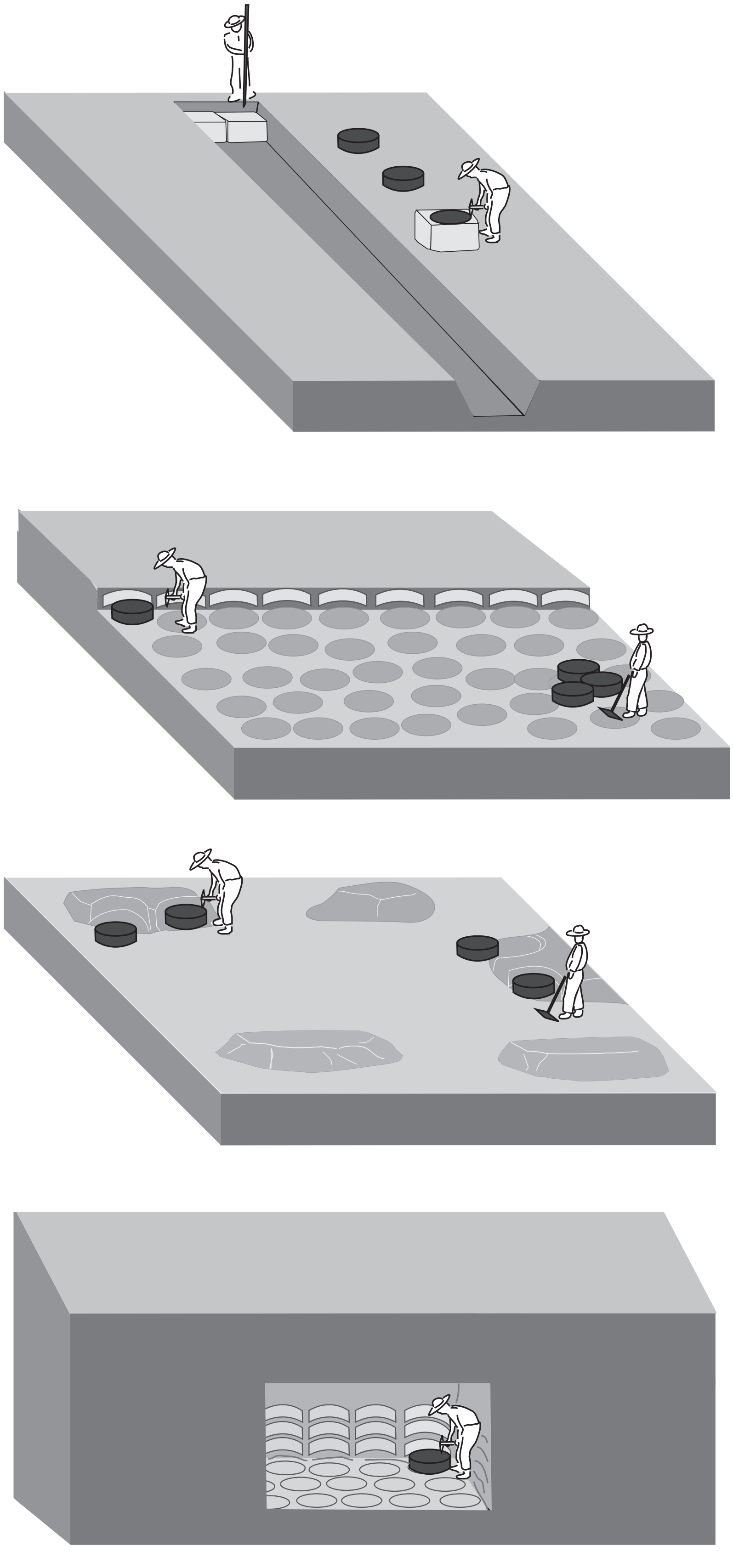
La question des meulières souterraines mérite quelques mots supplémentaires. L'identification d'un seul cas dans une si vaste zone d'étude est surprenante, surtout compte tenu de la longue tradition d'exploitation minière souterraine, commençant avec des puits pour exploiter le silex, par exemple sur le site néolithique de Vicálvaro à Madrid (Consuegra *et al.* 2004), aux galeries romaines souterraines pour exploiter l'argent et l'or à Murcie et à Almeria. Il y a aussi un certain nombre de carrières de construction souterraines romaines comme à Peñatejada à Cordoue (Penco Valenzuela *et al.* 2004: 235-238) qui fournissent de la pierre de taille à la ville romaine de Corduba, ainsi que des exploitations souterraines du Moyen Âge à Puerto de Santa María, Cádiz, qui ont fourni des blocs pour la cathédrale de Séville (Jiménez Martín 2006: 179).

Ailleurs en Europe, des meules en roche volcanique étaient extraites dans les galeries souterraines à Mayen, Eifel (Allemagne) (Hörter 1994; Harms & Mangartz 2002), et plus récemment au Mont-Vouan en Haute-Savoie, France (fouilles archéologiques dirigées par A. Belmont). Plus près de notre zone d'étude, au Maroc, de l'autre côté du détroit de Gibraltar, se trouve la célèbre « Grotte d'Hercule » (Tanger). C. Curwen, pionnier des études de meules, a pu observer l'extraction de meules dans les années 1950 dans cette grotte à la lumière des bougies (Peacock & Williams 2011: vii).

Dans notre zone d'étude, la seule meulière souterraine est à La Merced, Loja (GR-4b). Nous ne pouvons pas proposer une explication pour l'absence d'autres sites souterrains. Les recherches futures sur cette question vont certainement dévoiler plus de ces sites qui sont maintenant, sans doute, effondrés et cachés. En tous cas, La Merced (GR-4b) est une très petite exploitation avec quelques mètres de profondeur. Par conséquent, les fabricants de meules n'ont pas eu à faire face aux problèmes liés à de profondes galeries souterraines comme l'éclairage, la ventilation, la remontée de la nappe phréatique, et le problème de remonter des lourdes meules hors de la caverne.



Morphologie de meulières. Fig. 6.20: "en palier"; 6.23: "en poche"; 6.25: "de bordure"(extraction directe); 6.26: "de bordure" (extraction de blocs); 6.28: "en fosse" (dessins T. Anderson).



Morphologie de meulières. Fig. 6.30: "en tranchée"; 6.32: "extensives contigües superficielles"; 6.34: "extensive dispersé"; 6.36: "souterraine"(dessins T. Anderson).

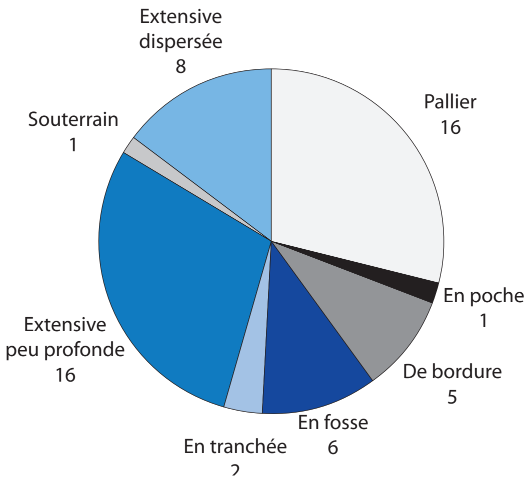


Fig. 6.39: Diagramme indiquant les proportions des huit classes morphologiques des meulières.

Commentaires sur la chronologie des catégories de meulières

De manière générale, les catégories de meulières suivent un schéma chronologique. Les travaux de surface simples travaillant les blocs de surface (MQ-1a) sont la plus ancienne forme d'exploitation, couvrant les périodes de la Préhistoire et de la Protohistoire. Il y a aussi des indices de ce type de travail à la fois à la période romaine et médiévale comme on le voit à travers certaines meules manuelles, parfois de mauvaise facture, faites avec des roches qui ne sont pas couramment exploitées dans les meulières extractives. Mais ce type d'exploitations, tant à l'époque romaine et que médiévale, étaient minoritaires, loin derrière les productions massives provenant à la fois de exploitations extractives directes de la masse rocheuse (MQ-2a) et de exploitations extractives de blocs (MQ-2b) (fig. 6.38).

Les meulières extractive de blocs (MQ-2b) sont également connues depuis des temps très reculés. Les sites de Zujaira (GR-12) (Anderson 2010, inédit) et d'El Barronal (AL-10) (Haro Navarro *et al.* 2006) ont vraisemblablement fourni des blocs détachés pour des meules à va-et-vient à partir des dalles. Encore une fois, ces travaux ont probablement été une exception et ont joué un rôle secondaire, loin derrière celui des exploitations de surface (MQ-1a). C'est lors de l'âge du Fer, avec la production de meules rotatives, que les meulières extractive de blocs (MQ-2b) atteignent un nouvel état, sans précédent. Bien qu'aucune exploitation de cette période n'a été identifiée dans notre zone d'étude, les centres de productions de meules rotatives pré-romaines à partir de blocs sont connus à travers l'Europe, notamment à Lodsworth en Angleterre (Peacock 1987), à Lovosiche en République Tchèque (Frölich & Waldhauser 1989), à Fossotes, La Salle dans les Vosges françaises (Farget & Fronteau 2011) et à Schweigmatt en Allemagne (Joos 1975).

Les meulières d'extraction directe (MQ-2a), comme Runnels l'a suggéré il y a déjà trois décennies lors de ses recherches sur les meules grecques de l'Argolide (Runnels 1981: 74), sont une innovation datant de l'époque romaine. Cette idée est appuyée récemment par L. Jaccottey (comm. pers.) basée sur des recherches menées depuis plusieurs années. Ceci est démontré par des exemples d'extraction directe dans plusieurs carrières de meules rotatives romaines, notamment à la Serre dans le Jura Français (Jaccottey 2011: 300) et dans trois cas en Suisse (Châbles FR, Chavannes-le-Chêne VD, et Würenlos AG) (Anderson 2006).

Un excellent exemple de l'évolution de la technique de détachement de blocs à l'âge du Fer à la technique d'extraction directe à l'époque romaine se trouve dans la vallée du Haut-Rhin. La technique de l'âge du Fer est illustrée par la meulière de Schweigmatt dans la Forêt-Noire allemande où ont été détachés des blocs de brèches rougeâtres. De toute évidence, les meules manuelles de Schweigmatt ont ensuite été supplantées lors de la période romaine par des meules provenant de meulières d'extraction directe en grès rose (*Bundsandstein*) (Anderson *et al.* 2003: 64, 66). Il y a certainement plusieurs raisons qui expliquent ce changement. L'emplacement de Schweigmatt, dans les collines de la Forêt-Noire, était moins accessible et la roche était moins étendue que celle des meulières de *Bundsandstein*, possiblement situées le long des rives du Rhin. Enfin, et c'est ce qui nous intéresse ici, c'est que les meulières extractives de grès rose ont éclipsé la production de Schweigmatt en raison de leur rendement plus élevé comme produits standardisés provenant de meulières d'extraction directe (Anderson *et al.* 2003: 64, 66).

Dans notre zone d'étude, des exemples datant de l'époque romaine de meulières à extraction directe (MQ-2a) mis en évidence sont le site volcanique de *Sisapo* (CR-1), à Ciudad Real, et les exploitations de biocalcarenite le long de la baie de Cadix, tels que Trafalgar (CA-1) et Rota (CA-3). Par conséquent, à ce stade de la recherche, dans le sud de la péninsule ibérique, toutes les preuves renforcent le modèle que les meulières employant la technique d'extraction directe (MQ-2a) ne sont apparues qu'après la conquête romaine. Mais il ne serait pas surprenant que des recherches futures réalisées dans notre zone d'étude puissent identifier des meulières pré-romaines employant cette technique de l'extraction directe, en raison de la longue tradition du travail de la pierre pour le statuaire et l'architecture de la culture protohistorique ibérique.

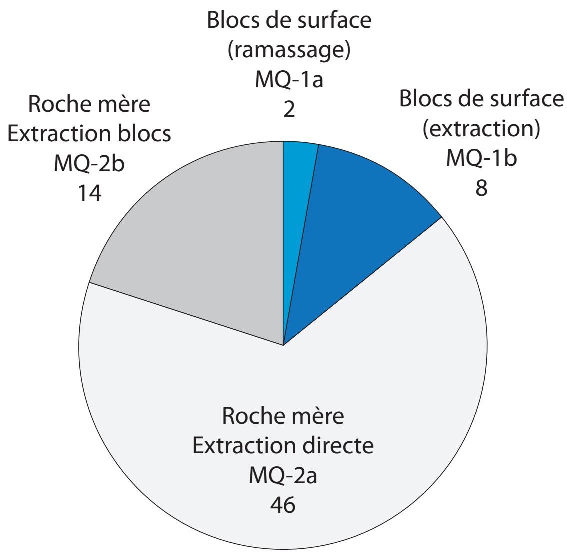


Fig. 6.38: Diagramme indiquant les proportions des différentes catégories de meulières. Exploitations du substratum rocheux (teintes grises), dominent de loin ceux des exploitations de blocs de surface (teintes bleues).

15.7. La toponymie de meulières

Bien que l'étude des noms de lieux est essentielle dans le cadre d'une recherche sur les meulières, les résultats dans le sud de l'Espagne n'ont pas été aussi concluants que ceux pour la France ou pour le nord de l'Espagne. En France, les toponymes Molière et Moulière du latin mola ont abouti à l'identification de nombreux meulières dans le Dauphiné français, certaines datant d'aussi loin que les XIIIe et XIVe siècles (Belmont 2006, Vol 1: 56-59). De même, les recherches de P. Pascual et P. García effectuées dans le nord de l'Espagne sur le toponyme *Molares* (meulière) et ses dérivés ont également abouti à l'identification d'un certain nombre de sites (Pascual & Ruiz 2011: 285-286).

Les recherches basées sur le nom *Molares* dans notre zone d'étude, en revanche, n'a permis d'identifier en revanche que quelques sites à Almonaster la Real, Huelva (HU-8), Molares, Cuenca (CU-1) et Tobes, Guadalajara (GUA-05). Il existe aussi des dérivées de *Molares*, également liés à la fabrication de meules comme le nom *Piedras Moleras* (CO-11) près de Villanueva de Córdoba. Il y a aussi une demi-douzaine de sites associés aux noms de *Moles*, *Mola*, *Molar* ou *Muelas* qui n'ont pas forcément une relation avec la production de meules. Il pourrait s'agir des noms liés à un élément topographique, notamment une butte ou un replat surmontant une colline (Sans Elorza 2012).

En revanche, il y a des sites relativement nombreux liés au nom *Cantera*, signifiant simplement « carrière »: Las Canteras, Colmenar de Oreja (M-2), Las Canteras, Granátula de Calatrava (CR-5), Cantera Honda, Paterna (CO-8), Las Canteras, Moclín (GR-1a), Rambla de las Canteras, Caniles (GR-11), Las Canteras, Ugíjar (GR-14), Cantera de las Pilas (CA-9), Las Canteras, Castillo de Locubín (J-1), Cantera de los Frailes, Cabra (CO-1), le Cerro de la Cantera, Huelma (J-3), Las Canteras, Guadalquitón (CA-13) et Las Canteras, Alhaurín el Grande (MA-3). Il est intéressant de noter qu'une partie de ces sites, contrairement à ce que leur nom suggère, ne montrent aucun indice d'extraction de pierres de taille et uniquement de fabrication de meules.

La faible proportion de noms de *Molares*, par opposition aux *Canteras* est intrigante. Nous nous demandons si ce changement de nom a été introduit au cours de l'afflux de tailleurs de pierres (*canteros*) d'autres régions de la péninsule, après la chute du régime islamique, pour travailler sur les nombreux projets architecturaux civils et religieux, ainsi que sur les carrières de meules.

15.8. L'infrastructure de meulières

La recherche dans le sud de l'Espagne en ce qui concerne les infrastructures de meulières est pratiquement inexistante. Comme nous l'avons indiqué à plusieurs reprises, aucun site n'a bénéficié d'une fouille archéologique qui pourrait faire la lumière sur les structures et les installations liées à leur exploitation. Cela nous oblige à faire recours à des observations réalisées lors de visites sur le terrain et sur quelques références de textes anciens. Nous comptons aussi sur les recherches menées dans le nord de l'Espagne, ainsi que les résultats des fouilles de quelques meulières ailleurs en Europe.

15.8.1. La réparation et l'entretien des outils

Les pics, ciseaux, broches et les coins des fabricants de meules, soit les outils qui ont servi à tailler et détacher la roche, devaient se soumettre à un entretien constant. Certains outils souffraient simplement de l'usure à un taux qui dépendait du type de pierre qu'ils taillaient. D'autres se cassaient lors de l'utilisation. D'une manière générale, leur réparation et leur entretien requéraient les compétences d'un forgeron et l'infrastructure d'une forge.

Les petites meulières n'ont pas eu un accès direct à une forge. Les travailleurs devaient planifier à l'avance le nombre d'outils à prendre sur le site afin de ne pas interrompre leur travail à la suite d'une cassure non désirée d'un outil. Les meuliers de ces petites productions ont dû compter sur un forgeron local, ou posséder les compétences et les outils nécessaires pour entreprendre les tâches du forgeron eux-mêmes. C'était, par exemple, le cas dans les meulières des montagnes de Palencia, où le meuliers s'occupaient eux-mêmes des réparations et de l'entretien (Maestro Hernández 2011: 38, 43). À Châbles, en Suisse, l'exploitation des meules manuelles avait accès à une forge voisine (Anderson *et al.* 2003: 59), tout comme la meulière de Gardom's Edge, Baslow, Derbyshire en Angleterre (Radley 1964) et celle de Vioménil en France (Vosges) du XVIIe siècle (voir Atlas du Millstone européenne carrières http://meuliere.ish-lyon.cnrs.fr/php/results2.php).

Il y a aussi des indices de présence d'une forge sur certains sites. C'est le cas sur les chantiers médiévaux du Mont Vouan en Haute-Savoie où les travaux d'extraction semblent avoir été si importants et intensifs qu'ils méritaient d'avoir leur propre forge. Celle-ci était placée au fond de la caverne-meulière de la Grand'Gueule (Belmont & Anderson 2010: 104-108).

Dans le sud de l'Espagne, nous n'avons observé aucun indice de forges sur les meulières. Ce type de travail ne laisse pas nécessairement de traces facilement observables en surface. Il faut noter, cependant, que toutes les forges identifiées dans des meulières ailleurs en Europe ont été découvertes dans le cadre de fouilles archéologiques. Il n'est donc pas surprenant de constater qu'aucune forge n'ait été mise en évidence dans notre zone d'étude.

Nous pouvons supposer que la grande production de Moclín (GR-1), par exemple, n'aurait pas eu besoin d'une forge sur place, car les travailleurs avaient accès à une forge dans le village, situées à quelques pas du site. En revanche, il est difficile d'imaginer que de grandes productions comme celle de El Berrueco (CA-8), à 10 km de la ville la plus proche (Medina Sidonia), et dotées d'une équipe de près de 50 travailleurs (Cruz y Bahamonde 1813: 91, note 1), aient pu fonctionner sans leur propre forge.

15.8.2. La gestion des débris

Les débris de travail générés par certaines meulières, comme celles qui exploitaient des blocs de surface, ou les exploitations extensives peu profondes discontinues, voire dispersées, ne posaient pas de problèmes particuliers pour les meuliers et n'empêchaient pas la poursuite des travaux. Sur d'autres sites, en revanche (en particulier sur les meulières en palier, en poche, en fosse, en tranchées ou sous terre), le débris augmentaient rapidement et devrait être évacués en continu afin de pouvoir poursuivre les travaux. Les meuliers étaient obligés de choisir un endroit pour les déposer le débris, de façon à éviter de devoir les déplacer une seconde fois.

Le déplacement des débris supposait de rechercher le moyen d'investir le moins d'effort possible (fig. 8.2). La solution la plus logique était d'évacuer les débris en contrebas, profitant de la gravité pour le transporter dans des paniers ou dans une brouette. Les débris étaient ensuite déposés en tas (ou halde). Ce fut relativement simple dans le cas de meulières en palier ou en poche situées, par définition, sur des pentes.

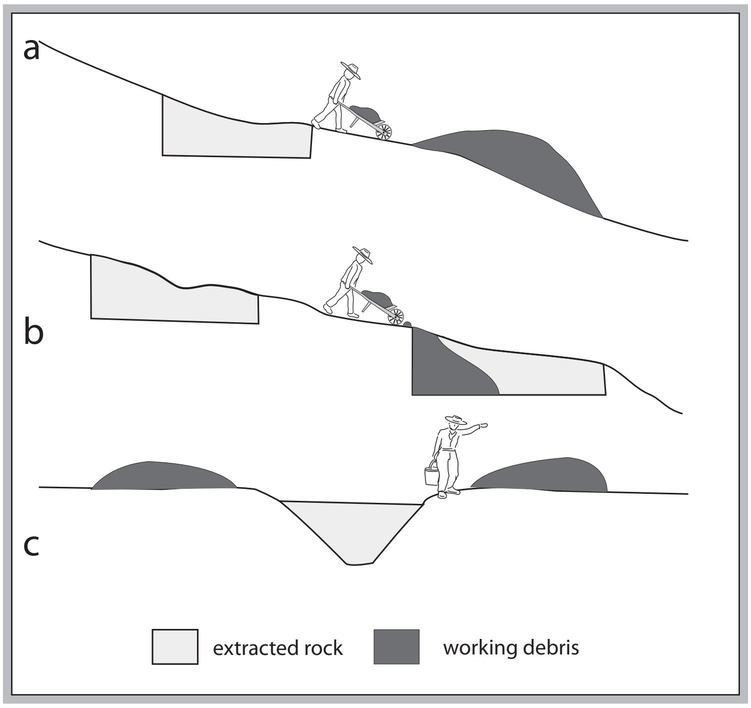


Fig. 8.2. Schéma illustrant la gestion des déblais dans les meulières a) halde en aval; b) remblayage des secteurs terminés; c) débris placé en longs cordons le long de la tranchée (dessin T. Anderson).

Dans le cas des meulières en tranchées, des débris ont été déposés juste à l'extérieur de la tranchée. Au fil du temps, des tas contigus ont donné lieu à de longs cordons parallèles. Pour des meulières en fosse ou en tranchée, en fonction de leur profondeur, des chemins devaient être aménagées pour évacuer les débris. À certains moments, les meuliers érigeaient même des murs en pierres sèches qu'ils remblayaient avec des débris. Ces structures servaient alors de rampe, à la fois pour entrer et sortir des zones de travail.

Dans les meulières très profondes, le meuliers installaient des systèmes de cordes (éventuellement avec des poulies) pour soulever les sacs de débris. Dans des périodes récentes, certains mécanismes comme des cabestans ont été mis à profit pour faciliter le déplacement de matériaux lourds, les débris probablement compris, comme on le voit par exemple dans les meulières de l'Eifel (Allemagne) et de Selbu (Norvège).

Dans certains cas, les travailleurs remblayaient des secteurs terminés. C'est le cas de quelques exploitations souterraines au Mont Vouan en France, récemment l'objet de fouilles archéologiques (A. Belmont, dir.). La fouille de ce type de remblai permet les archéologues de mettre en évidence les marques d'outils bien conservées sous les débris et, par le biais de la stratigraphie verticale, étudier comment le secteur a été remblayé.

D'une façon générale, la tâche ingrate de déplacer les débris a probablement été réservée aux nouveaux membres des équipes. Il est également possible d'imaginer que cette tâche a été menée par des femmes et des enfants.

15.8.3. Résidences et abris

Tailler une seule grande meule nécessitait plusieurs jours de travail. Si la meulière se trouvait loin d'une agglomération, les travailleurs ont été obligés, au moins pendant certaines périodes de l'année, d'être logés la nuit. Si le travail était intense et permanent, les travailleurs devaient être abrités soit de manière saisonnière ou permanente.

Selon nos observations de terrain, des meuliers ont parfois construit de simples refuges pour s'abriter durant de courtes périodes. De petits refuges en pierres sèches, avec de la place que pour quelques hommes, ont été par exemple érigés sur les sites d'El Lachar (J-2) et d'El Torcal (MA-1). À El Torcal il y a même des indices d'un enclos qui pourrait avoir servi pour des bœufs, les animaux utilisés pour le transport des meules. Sur les sites souterrains, la caverne elle-même aurait pu servir de lieu pour passer la nuit. Malgré sa simplicité, la petite maison à poteaux située à côté de la meulière romaine de Châbles-Les-Eaux en Suisse (Anderson *et al*. 2003, chapitre 8), aurait fourni un cadre confortable pour le meulier.

La situation de résidence de la meulière de Berrueco (CA-8) était très différente. Nous savons par le récit de la Cruz y Bahamonde, datant du début du IXXe siècle, que cette vaste production comptait 50 travailleurs qui étaient hébergés sur place (Cruz y Bahamonde 1813: 91, note 1). C'est le seul exemple dans notre zone d'étude où il existe une source écrit qui démontre l'existence de logements pour les travailleurs. Cette source, cependant, ne renseigne pas sur les conditions ou la quantité du loyer.

La situation des hébergements d'autres productions était encore différente. Les grandes meulières de Moclín (GR-1) et de Cabra (CO-1) étaient très proches de la ville. Dans ces cas, les travailleurs permanents rentraient probablement chez eux le soir, tandis que les travailleurs itinérants pouvaient éventuellement trouver un hébergement dans une auberge.

15.8.4. Le transport des meules

Le concept du transport des meules comprenait deux étapes fondamentales. La première est celle de retirer la pierre de son lieu d'extraction, souvent de accès difficile. C'est depuis ce point, toujours près de la meulière, où la première étape du voyage de la meule était initiée, soit à destination d'un atelier pour sa finition, soit directement au moulin. Ce voyage, en fonction de sa distance, pourrait comprendre plus d'un moyen de transport, soit par terre, par eau ou, plus récemment, par le rail.

En fonction de la taille de la pierre, du type d'exploitation et du terrain environnant, le déplacement des meules de leur lieu d'extraction n'était pas simple. Un certain nombre de carrières n'étaient pas forcément accessibles pour les charrettes ou les animaux. Ainsi, pour faciliter le déplacement, les meuliers ont construit des « *slipways* » (pistes ou cales), des rampes en utilisant des débris de pierre, des rails ou encore des pistes en bois. Lorsque les animaux de trait peuvent atteindre les zones d'extraction, ils les tiraient sur des traîneaux (fig. 8.17) de différentes formes pour faire glisser la pierre jusqu'à la charrette. Au cours de ce processus, les fabricants de meules les enveloppaient par exemple dans les roseaux afin de ne pas nuire à leur produit (Maestro Hernández 2011: 46).

À certains moments, le transport jusqu'à sa destination finale était très court, et le même traîneau utilisé pour tirer la meule de son lieu d'extraction pouvait être utilisé pour l'amener jusqu'au moulin. Il y a même des cas où quelques hommes, assistés ou non par des animaux, ont utilisé la méthode du "rolling stone" en insérant une poutre en bois à travers l'œil afin de la transformer en roue (fig. 8.18). Cette méthode, attestée par voie orale sur un certain nombre d'occasions et illustré par Gómez Ruíz (2003: 85, fig. 7), était certainement limitée à des cas exceptionnels de transport pour de très courtes distances.

La plupart des transports de meules ont été menés par des charrettes à plateformes plates, tirées par des mules ou des bœufs (fig. 8.15). Ce transport pouvait être organisé soit par les fabricants de meules eux-mêmes, qui, comme agriculteurs, étaient propriétaires d'animaux de trait. Dans d'autres cas, ils ont été transportés par des professionnels (*carreteros*).

Dans le cas d'un transport plus lointain, les voies fluviales et maritimes étaient une alternative utilisée depuis l'Antiquité. Le naufrage du IVe siècle avant J.-C. à El Sec (Arribas 1987), au large de la Baie de Majorque, a été chargé des moulins à trémie d'Olynthe et quelques modèles de type Morgantina. De même, le naufrage du IIe siècle avant J.-C. à Illa Pedrosa, au large de la côte de Catalogne, transportait une cargaison de 130 meules rotatives (Vivar 2004). Dans notre zone d'étude, aucun naufrage de ce genre n'est signalé. Toutefois, la présence de meulières en biocalcarenite le long de la Baie de Cadix à Trafalgar (CA-1) et Chipiona (CA-6) suggère le transport de meules par voie maritime et les sources écrites font aussi référence à des transports maritimes au XVIe (Fernández López 1982: 221, note 10) et IXXe siècles (Ponce 1981).

Le transport de meules par chemin de fer dans le sud de l'Espagne s'est développé très tardivement, à partir de la seconde moitié du IXXe siècle, après l'achèvement du réseau ferroviaire. Bien qu'il n'y ait aucune preuve, nous supposons que les grands producteurs de meules du sud de l'Espagne ont profité de ce nouveau moyen de transport comme l'ont d'ailleurs fait les producteurs de pierres de taille. Les conséquences de ce transport ferroviaire ont été ironiquement l'arrivée de meules françaises qui ont fini par saper tous les centres de production de meules régionaux du sud d'Espagne.

Fig. 8.18: Reconstruction d'une scène de déplacement d'une meule au moyen de la technique du "rolling stone" (dessin Gómez Ruiz 2003: 85, fig 7).

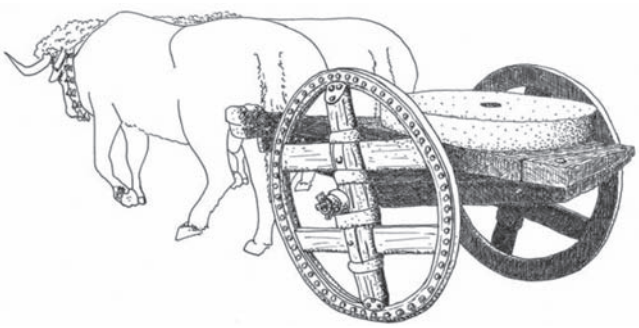


Fig. 8.15: Reconstruction d'une charrette tirée par des bœufs sur la base d'informations provenant de la région de Navarre (Pascual et al. 2011: 250, fig. 25, dessin Javier Castro).

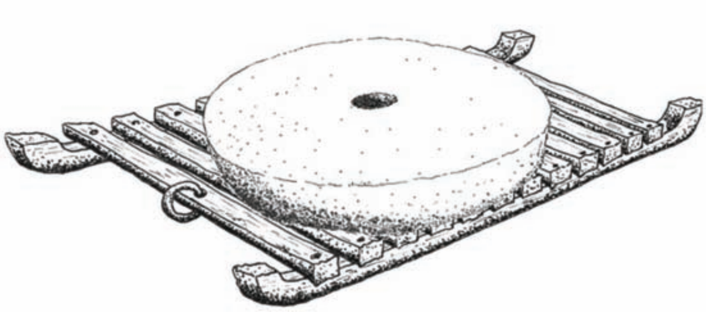


Fig. 8.17: Reconstruction d'une narria, *sorte de traîneau, pour transporter des meules (Pascual Mayoral et al. 2011: 249, fig. 23; dessin Javier Castro).*

15.9. Les hommes derrière les meules

Le profil du fabricant de meules, son degré de spécialisation et sa place dans la société sont des notions difficiles à juger par la documentation actuelle.

Les premiers fabricants de meules à va-et-vient étaient d'abord des agriculteurs et des éleveurs. Ils avaient certainement une excellente connaissance de la roche à travailler, comme on le voit à travers la longue tradition de fabrication des outils de pierre, la fabrication des habitations en pierre, et la construction de structures défensives et funéraires. Néanmoins, tailler des meules était loin de leur activité principale.

Cette situation a changée au cours de l'époque romaine. La production à grande échelle de moulins à bras et de moulins à systèmes de traction plus sophistiqués et plus standardisés pour une population croissante, a fournie aux meuliers un travail au moins saisonnier, si non à temps plein. Travailler dans des meulières romaines exigeait de nouvelles compétences dans la fabrication de meules, en particulier celle de l'extraction de cylindres directement à partir du socle rocheux (MQ-2a). À ce stade, nous pouvons considérer les meuliers comme de véritables spécialistes.

Au Moyen Âge, et pendant la domination islamique, nous perdons la trace des meuliers. Ils sont certainement restés des travailleurs hautement spécialisés en raison de la demande de meules pour un nombre croissant de moulins hydrauliques construits le long des rivières et des ruisseaux, ainsi que la longueur des canaux d'irrigation qui se développent à travers le paysage. Il peut ainsi y avoir eu des meulières fournissant un travail permanent. Mais l'absence de roche dominante, tels que les matériaux volcaniques à l'époque romaine exportés sur de longues distances, a probablement réparti le travail dans des meulières locales et régionales, les obligeant de combiner leur travail en meulière avec d'autres travaux de la pierre (pierre de taille) ou d'autres actitivtés telles que l'agriculture.

Fig. 9.1: Photo datant de 1933 de moleros (meuliers) de Brañosera (Palencia) dans le nord de l'Espagne. Certains sont identifiés par leur nom dans l'étude de Maestro Hernández (2011: 40): à gauche sont père et fils Manolo et Antonio García; dans le fond un seul des hommes, Gerardo, est identifié. Herminio Miguel est au premier plan et à droite, c'est son fils Sauro (photo de Cuevas Ruiz 2006).

La situation semble être similaire après la chute du régime islamique. Juan de Bargas, au début du XVIIe siècle dans la province de Córdoba, a travaillé à la fois comme meulier et tailleur de pierre pour des projets de construction (González Peralbo 2008). Cette dualité de travaux a été probablement causée par le manque de commandes régulières de meules qui l'obligeaient à exercer d'autres travaux, toujours en relation avec la pierre.

La situation à l'époque contemporaine a probablement continuée comme auparavant avec les meuliers qui travaillaient selon des commandes spécifiques. Il existe cependant des preuves de la montée de certains centres de production qui ont eu la capacité d'engager des meuliers professionnels à temps plein ou au moins sur une grande partie de l'année. El Berrueco (CA-8) à Cadix au début du IXXe siècle disposait de 50 travailleurs (Cruz y Bahamonde 1813: 91, note 1) et un demi-siècle plus tard avait 23 hommes, répartis en cinq ateliers différents (Madoz 1848, Vol. 11: 343).

Ces meuliers ont certainement été divisés en équipes avec des maîtres qui veillaient à maintenir le rythme et la qualité de la production. Ces maîtres avaient pu acquérir le droit de concessions et donc auraient gagné profit (cf. fig. 10.2). Ce bénéfice, et le contact avec les propriétaires de la meulière, nobles ou ecclésiastiques, auraient augmenté leur statut social.

La spécialisation et l'intensité du travail sur ces sites de production plus importants auraient été accompagnées par des risques professionnels, tels que le danger immédiat pour les yeux et les membres. Les accidents sur les chantiers n'étaient probablement pas rares. Le plus grand danger était néanmoins à plus long terme. Selon le type de roche, les meuliers ont pu souffrir de la longe et silencieuse silicose, une maladie qui pouvait anéantir un homme en bonne santé dans un certain nombre d'années.

15.10. La propriété et le contrôle des meulières

Il y a très peu d'indices concernant la propriété et le contrôle des meulières dans notre zone d'étude. En général, et à travers le temps, nous supposons que de modestes exploitations utilisées pour la consommation locale sont probablement passées inaperçues ou étaient ignorées par les autorités. Les travaux de surface le long des lits de rivières ou de talus, par exemple, auraient été extrêmement difficile à contrôler. Les extractions isolées dans des zones reculées, loin des centres urbains, sont également restées inaperçues. Par contre, de grands centres de production avec un fort potentiel de profit, ont certainement attiré l'attention des autorités.

Ces grandes productions ont probablement attiré l'attention des autorités dès l'Antiquité. À cette époque, la production de certaines meulières, en particulier dans les districts volcaniques, a atteint un niveau très élevé et les propriétaires des terres où elles se trouvaient et/ou les autorités politiques locales avaient sûrement convoité leur contrôle, comme les autres sources potentielles de richesse telles que les mines.

Au Moyen Âge, sous la domination islamique, avec l'abandon des exploitations volcaniques, la plupart des productions semble avoir été reparties au niveau local et régional, profitant d'une série de roches sédimentaires. Il est raisonnable de supposer que les petites productions de surface restent anonymes et ne reçoivent pas l'attention des autorités. Mais les plus grands centres, notamment les exploitations d'extraction directe de grandes meules pour des moulins hydrauliques, ont pu être soit sous le contrôle direct des autorités, ou les instances dirigeantes étaient obligés verser des taxes pour le droit de production et de commercialisation.

Après la reconquête, les centres de production sont passés directement sous l'autorité des instances dirigeantes, comme indiqué par les codex juridiques et les sources historiques. Le *Fuero de Cuenca*, par exemple, est un ensemble de lois datant de la fin du XIIe siècle qui règlait le transfert de propriétés après la reconquête. Il est sans équivoque sur la question de la propriété de ces sites:

"*Tous les lits de gypse, **meulières** et tuileries, ainsi que les sources d'eau pérennes, devraient être propriété commune du conseil. Celui qui a une **meulière** ou autre propriété mentionnée précédemment sur sa propriété devrait la vendre au conseil pour une propriété de double taille, et il devient communal. Si quelqu'un l'occupe contre un autre du conseil, il doit payer cent aurei* » (J. Powers 2000: 57).

Il y a plusieurs autres exemples dans les anciens textes qui illustrent le contrôle des autorités (membres de la noblesse et du clergé) sur la production de meules, ainsi que les autres activités commerciales. Le conseil de Loja en 1502, par exemple, interdit au moyen d'une proclamation orale (*pregón*), l'extraction de meules sans l'autorisation, sous la menace de confiscation non seulement de la meule, mais les bœufs utilisés pour son transport (Pregón 1502, enero, 10. Loja,). Au Llerena (BA-2) en Estrémadure, une ordonnance municipale de 1566 interdit aux « étrangers » d'extraire des meules de la meulière locale, à moins qu'ils ne paient (comme les gens du pays) le tarif officiel (http://manuelmaldonadofernandez3.blogspot.com.es/2010_04_01_archive.html). En 1501, la dispute entre les conseils d'Antequera et de Malaga sur le droit d'extraire des meules dans les terres placées sous l'autorité du conseil d'Antequera, a été amené jusqu'aux plus hautes autorités à l'époque, des Rois Catholiques Ferdinand et Isabelle à Grenade (Fernández López 1982: 222-223; AML, Leg 49, p 9 1 cuartilla + 1).

À l'époque contemporaine, la situation a peu changé. Dans la province de Cadix, la dynastie de la famille du Duc de Medina a maintenu non seulement le contrôle de la meulière de El Berrueco (CA-8) durant plusieurs siècles, probablement l'une des plus grosses productions du sud de la péninsule ibérique, mais également le contrôle d'un grand nombre de moulins à eau. Il y a également un texte qui indiquent qu'au début du IXXe siècle, la famille recevait 18 meules par an en échange de la concession de la meulière (Cruz y Bahamonde 1813: 91, note 1). Cela a été très profitable pour la famille parce que non seulement ils ont reçu gratuitement les meilleures meules régionales, mais ils pouvaient également les utiliser pour remplacer les pierres des moulins hydrauliques qu'ils possédaient.

La meulière de Berrueco avec sa grande production qui était sous l'autorité de la noblesse locale est probablement typique de l'époque contemporaine. Ces sites ont dominé le marché régional. Cependant, les petites productions comme celles décrites par Maestro Hernández

(2011) qui fonctionnaient de façon intermittente dans les montagnes de Palencia (fig. 9.1), n'ont pas disparues. Ces centres modestes ont offert une alternative plus économique aux meules provenant des grandes meulières. Cependant, ces meules n'ont certainement pas livrée de la farine blanche, si recherchée pour le pain blanc.

Fig. 10.2: En haut: vue aérienne de la meulière Cantera de los Frailes, Cabra, Cordoue, La fronts semblent s'aligner dans des compartiments (interprétés en rouge en bas) qui pourraient correspondre à des concessions contratés à des meuliers (SIGPAC).

15.11. La chronologie des meulières

15.11.1. Méthodologie

Établir la chronologie d'une meulière n'est pas une tâche simple. Il est bien connu par des exemples en France et en Suisse qu'une roche munie d'excellentes propriétés de mouture pouvait avoir été exploitée pendant une longue période de temps - des siècles ou plus. Cela se voit dans certains sites disposant d'une large gamme d'extractions, depuis des petites meules rotatives aux grandes meules hydrauliques. Cependant, les sites produisant un produit unique et standardisé ont probablement été de courte durée, comme cela semble être le cas des meulières romaines de Cerro de Limones (AL-1) et d'Hoya del Paraíso (AL-2) (Almería).

Sources écrites

Il y a un certain nombre d'indicateurs qui aident à définir la chronologie des meulières (fig. 11.1). Le premier se rapporte aux sources écrites, avec, par exemple, des archives historiques, notariales et textes anciens géographiques et géologiques (fig. 11.2). Aussi utiles qu'elles soient, ces sources fournissent le plus souvent qu'un *terminus* qui reflète la production au moment où le texte a été écrit, mais n'informe pas sur de potentiels phases de travail plus anciens ou plus récents. Des exceptions se trouvent lorsqu'un site bénéficie de plusieurs sources écrites couvrant une large période, comme c'est le cas d'El Torcal (MA-1), de Loja (GR-2/3) et d'El Berrueco (CA-8). Ces exploitations sont citées dans des textes datant de la transition entre les XVe et XVIe siècles, jusqu'au IXXe siècle (cf. fig. 11.26).

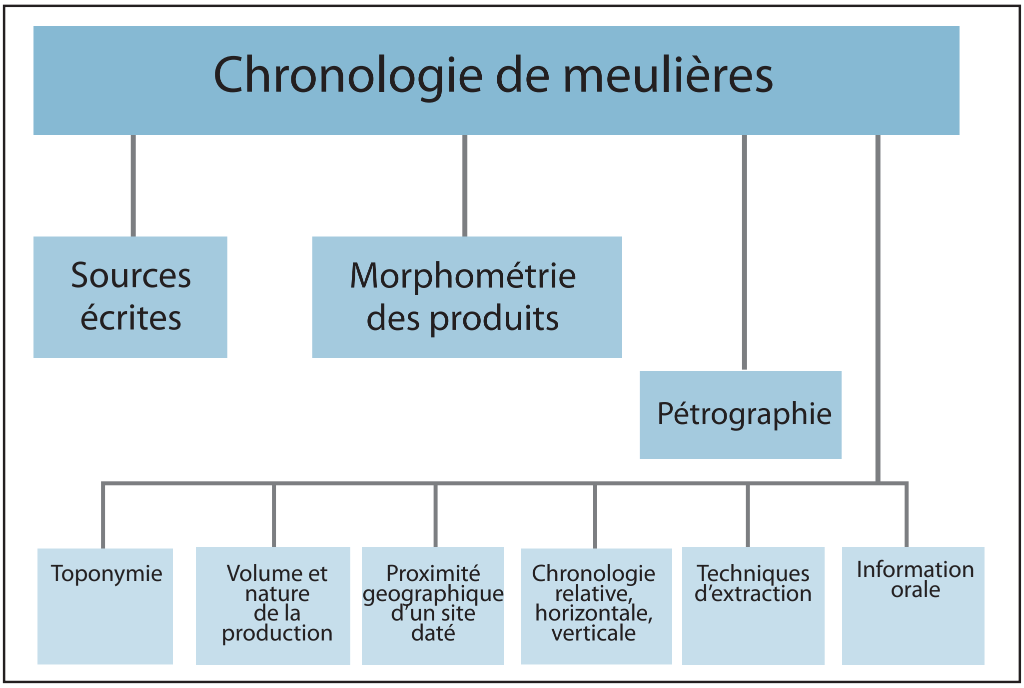


Fig. 11.1: Organigramme de la hiérarchie des principaux indicateurs pour établir la chronologie des meulières.

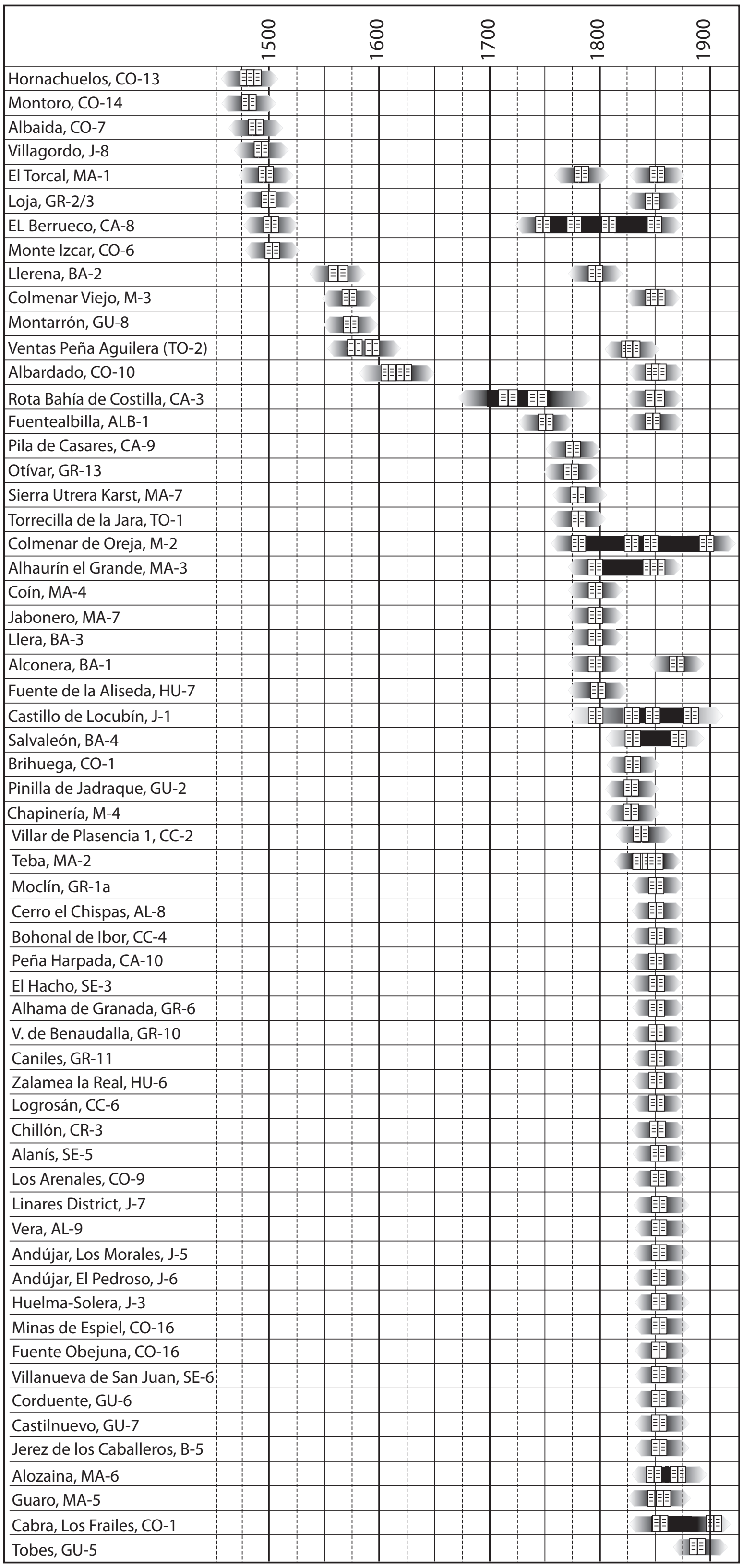


Fig. 11.2: Tableau chronologique des meulières mentionnées par les sources écrites entre la fin du XIVe et le début du XXe siècle. Le symbole au centre de la page représente l'année de publication du document. De manière à refléter une période estimée de production, les flèches avec des dégradés en gris indiquent (arbitrairement) 25 ans avant et après l'année du document. Certains de ces sites sont mentionnés dans plus d'une source montrant une période d'exploitation prolongée.

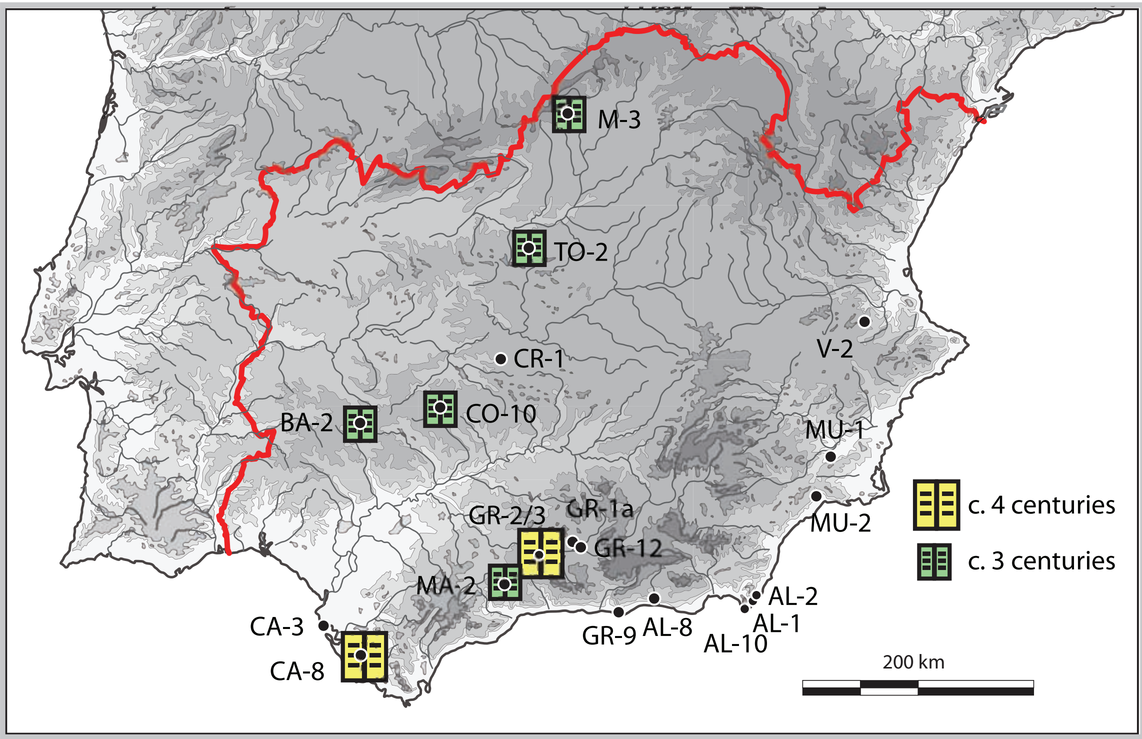


Fig. 11.26: Les symboles indiquent les sites avec une continuité probable de la production de trois à quatre siècles sur la base des sources écrites.

Morphométrie

Le deuxième indicateur de la chronologie est la morphométrie de 1) les meules inachevées et/ou 2) les alvéoles. En général, les grandes alvéoles ou les cylindres, par exemple, tendent à suggérer une datation plus récente, au cours des derniers siècles, tandis que les petites extractions de meules manuelles suggèrent généralement (mais pas toujours) une datation allant de l'Antiquité au Moyen Âge. Ces informations, en tout cas, sont le point de départ pour une datation plus fine atteinte en combinant d'autres indicateurs chronologiques.

Il faut noter que les produits abandonnés dans les meulières, en raison de leur caractère inachevé, portent rarement des éléments typologiques (logements d'anille, trous de manchons) à partir desquels des datations plus fines peuvent être obtenues.

À partir des mesures recueillies sur des meulières, dans des dépôts de musées, et en consultant le peu de littérature molinologique, nous arrivons aux indicateurs morphométriques suivants (fig. 11.7), qui servent à déterminer les tendances chronologiques des meulières du sud de l'Espagne.

1 — Les extractions de meules de diamètre allant de 35 à 42 cm correspondent le plus souvent à des moulins manuels de l'âge du Fer et/ou de la période romaine. Les modèles de l'âge du Fer sont généralement plus petits que les modèles romains. Pour compliquer les choses, des meules manuelles médiévales, bien que généralement plus grandes que ceux de l'âge du Fer et romains, sont également connues dans cette gamme de diamètre. La différence est que celles provenant de l'âge du Fer et de la période romaine, dans l'ensemble, sont proportionnellement plus épaisses que celles du Moyen Âge.

2 – Des extractions minces, discoïdes de 50 cm de diamètre peuvent être attribuées, avec un degré de confiance élevé, à des meules manuelles du Moyen Âge. D'autres modèles de ce diamètre plus épais et sont des meules de fourrage pour les animaux (molinos de cebo) de l'époque contemporaine.

3 — L'indicateur de diamètre 60 à 90 cm est le plus complexe et couvre toutes les périodes chronologiques depuis l'âge du Fer. En général, des extractions en forme de "tambour" (aussi épaisses que larges), à l'âge du Fer et à la période romaine sont des moulins cylindriques. La tendance pour des modèles de moulins cylindriques romains est d'être légèrement plus grands. Les modèles discoïdes bas de cette gamme sont supposés être des moulins à sang ou hydrauliques allant du Moyen Âge à l'époque contemporaine. La gamme de 60 à 90 cm, donc,, n'est pas valable pour établir une datation (indépendamment des autres indicateurs).

4 – Des extractions cylindriques pourvues d'un diamètre allant de 1,00 m à 1,50 m peuvent dater d'au moins de la fin du Moyen Âge jusqu'à l'époque contemporaine. Cette gamme, quoique peu utile pour une datation fine, permet néanmoins de rejeter les périodes antérieures.

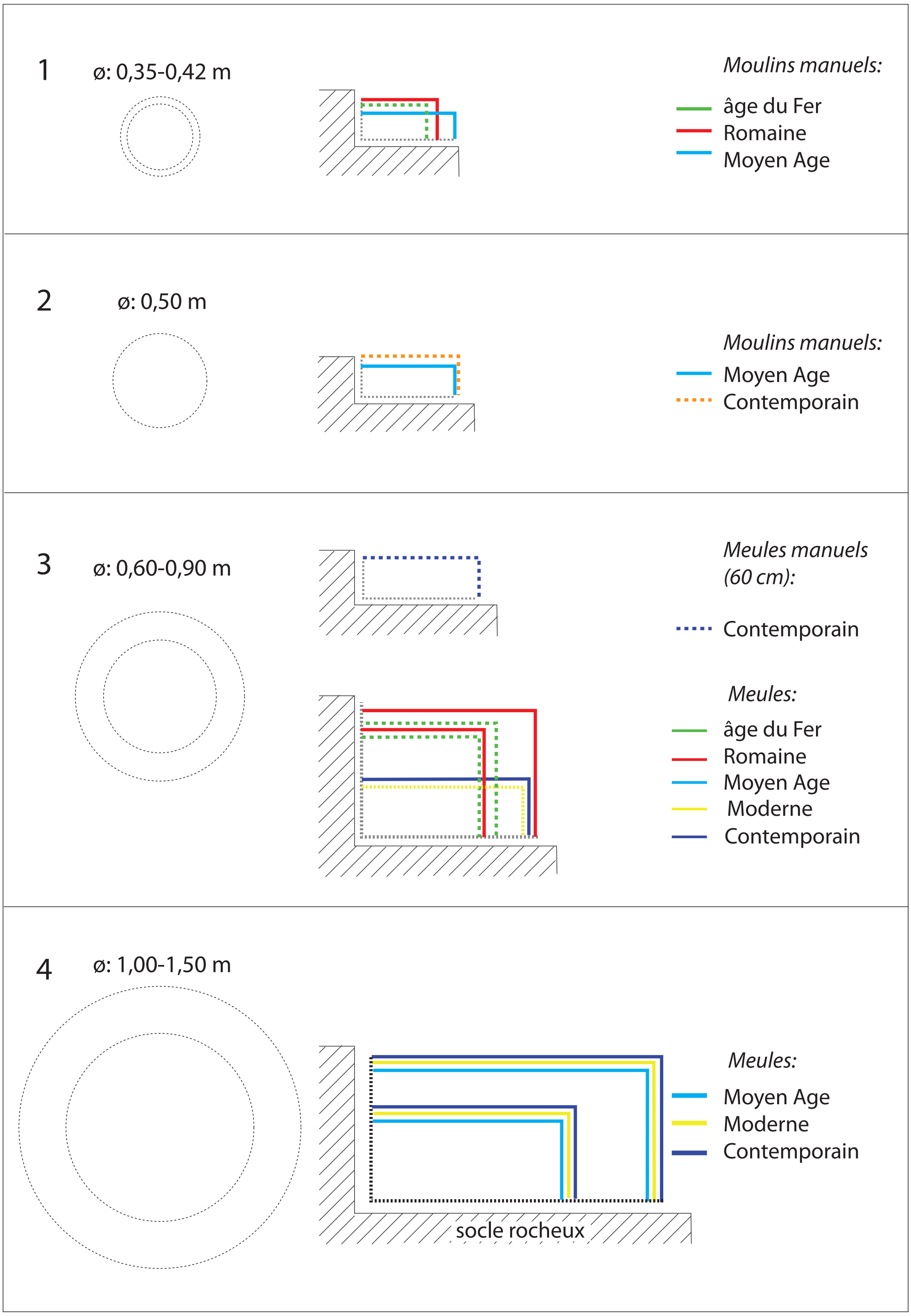


Fig. 11.7: Schéma illustrant les quatre grandes catégories d'extraction de meules (selon les dimensions des cylindres ou des alvéoles) sur la base des proportions approximatives du diamètre et de l'épaisseur. Les diamètres des produits se chevauchent dans les différentes périodes chronologiques notées à droite de chaque schéma. Ce chevauchement, surtout dans le cas de 3, complique la datation. Dans ces cas, les d'autres indicateurs sont nécessaires pour établir leur chronologie (dessin T. Anderson).

Petrographie

La pétrographie est un indicateur précieux, car il y a des périodes où certaines roches ont été plus prisées que d'autres. Les matériaux volcaniques (dacites, rhyolites, lamproïtes et basaltes) sont généralement symptomatiques de l'époque romaine, alors que les calcaires blancs sont le plus souvent associés à des productions modernes ou contemporaines.

Autres indicateurs

Il y a, à un niveau inférieur,une série d'indicateurs chronologiques: 1) les noms de lieux, 2) la proximité géographique d'une meulière à un gisement daté (fig. 11.8), 3) la chronologie relative et la stratigraphie verticale (fig. 11.24), 4) les techniques d'extraction et 5) des informations orales. Tous ces indicateurs subsidiaires, appliqués de façon indépendante, ne suffisent pas pour établir une date fiable. Ils servent, cependant, à renforcer ou à corroborer des indicateurs chronologiques plus fiables (sources écrites, morphométrie et pétrographie).

Fig. 11.8: Vue aérienne des affleurements volcaniques (dômes) exploités pour des meules (CR-1) et leur alentours (500 m) avec la ville romaine de Sisapo (SIGPAC).

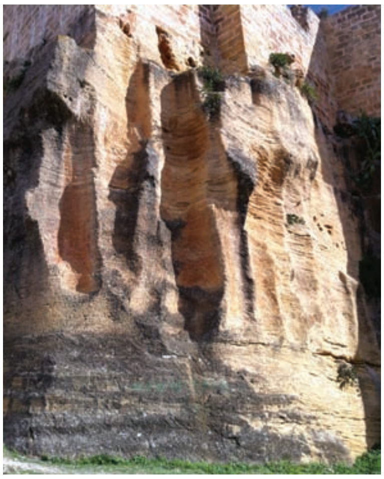


Fig. 11.24: Vue d'un des fronts de la meulière de Montesa (V-2). Les extractions supérieures situent à la base des fondements d'une fortification. Il semble que ces extractions sont perturbés, donc antérieures, au construction du château, plaçant la carrière probablement sous période islamique (photo J. García Cerda).

15.11.2. Les assemblages chronologiques

Pour illustrer la chronologie des meulières que nous avons identifiées dans le sud de la péninsule ibérique, nous les avons divisés en trois assemblages, représentés dans trois tableaux.

Assemblage chronologique 1 (tableau 11.2)

Ce tableau représente les meulières plus anciennes, depuis la Préhistoire récente ou Protohistoire jusqu'à l'époque médiévale, dans l'ordre chronologique croissant et en fonction de leur première phase de production reconnue. Ces sites ont livré des meules à va-et-vient, des meules rotatives manuelles, des meules à sang cylindriques, et de petits modèles de meules hydrauliques. Certains sites, comme Rota (CA-3), Moclín (GR-1) et Castillo de Locubín (J-1), présentent également des phases d'extraction plus récentes certifiées par les textes. L'indicateur pétrographique, en particulier pour les productions volcaniques, est essentiel pour établir la chronologie d'une série de sites romains.

Assemblage chronologique 2a et 2b (tableau 11.3a et 11.3b)

Ces assemblages sont établis exclusivement à partir des sources écrites et sont illustrés dans deux tables séparées par un intervalle d'environ 30 ans. La liste de ces sites, comme celle de la première table, suit l'ordre selon leur première phase d'extraction. Étant donné que ces sites peuvent être définis très précisément, cette table (contrairement à celui du tableau 11.2) est divisée en colonnes représentant des siècles. Le premier assemblage (2a) (tableau 11.3a) correspond grosso modo à la période moderne et présente des sites allant de 1481 à 1794. Il est divisé en quatre sous-groupes (a, b, c, d).

L'assemblage 2b, bien que la continuation de la première désigne le passage de la période moderne à l'époque contemporaine (fin du XVIIIe siècle). La plupart des meulières de cet assemblage sont identifiées dans les dictionnaires de Minano (1826-1829) et de Madoz (1845-1850). Quelques-unes, à partir de la fin du IXXe ou du début du XXe siècle, sont datées à partir d'autres sources écrites ou orales.

Parmi l'assemblages 2 (cf. fig. 11.26 plus bas,) il y a un serie des sites qui montrent des indices, selon les sources écrites, d'une exploitation de trois, voir quatre, siècles.

Assemblage chronologique 3 (ableau 11.4)

Ce dernier tableau enregistre la datation approximative des meulières restantes qui ne bénéficient pas de moyens de datation à l'exception de la grande taille de leurs extractions. Tous ces sites comprennent des extractions d'un diamètre de 1,00 m ou plus. Par défaut, ils datent d'entre le Moyen Âge et l'époque contemporaine. Seules des recherches futures, à la fois sur le terrain et dans les archives historiques, pourraient fournir des informations plus précises quant à leur datation.

Tableau 11.2: Tableau chronologique des meulières de la préhistoire au Moyen Age. Ce tableau illustre, pour la plupart, des sites dépourvus de sources écrites. Rota (CA-3), Moclín (GR-1) et Castillo de Locubín (J-1), identifiées par des sources écrites, figurent dans ce tableau en raison de leurs phases anciennes d'extraction de meules manuelles.

Code	Site	Certified	Neolithic Chalcolithic Bronze Age	Late Iron Age	Roman	Middle Ages	Modern	Contemporary
AL-10	El Barronal	no						
MU-2	Mazarrón	no	?		?			
GR-12	Zujaira	yes	?		?			
CO-15	Almedinilla district	no		?	?			
AL-1	Cerro de Limones	yes						
AL-2	Hoya del Paraiso	yes						
CR-1	Sisapo	yes						
CR-2	Las Herrerías	yes						
CR-6	Cerro Columba	no			?			
AB-2	Cancarix	no			?			?
CA-1	Trafalgar	yes						
CA-3	Playa de Costilla, Rota	yes						
CA-2	Pta. Camarinal/Pta. Paloma	yes			?			
MU-4	Fortuna	no			?			
BA-6	Mérida district	no			?			
SE-7	Gerena District	no			?			?
CO-11	Piedras Moleras	no			?	?		
CC-3	Villar de Plasencia 2	no						
A-2	Barranco Molinos, Ibi	no						
GR-5	Zagra	yes						
SE-1a	Almadén de la Plata	yes						
SE-1b	Almadén de la Plata	yes						
SE-2	El Pedroso	yes						
GR-4a	La Merced 1	yes						
MU-1	Puerto de la Cadena	yes						
AL-3a	Rambla Honda	yes						
AL-3b	Los Leonardos	yes						
GR-4b	La Merced 2	yes						
V-2	Montesa, La Mola	no						
GR-9	Playa de Carchuna	yes						
HU-8	Almonaster, Los Molares	no				?		
AL-8	Cerro el Chispas	yes						
J-1	Castillo de Locubín	yes				?		
GR-1a	Moclín	yes						
CO-12	El Patriarca	no						

Tableau 11.3a: Assemblage chronologique 2a basé sur des sources écrites publiées entre 1481 et 1794. Environ un tiers révèlent des phases de travail ultérieures identifiées par des autres sources écrites.

	Code	Site	Surveyed	Middle Ages	Modern (1500, 1600, 1700)	Contemporary (1800, 1900)
a	CO-13	Hornachuelos	no			
a	CO-14	Montoro	no			
a	CO-7	Albaida	no			
a	J-8	Villagordo	no			
a	MA-1	El Torcal	yes			
a	GR-2/3	Loja	yes			
a	CA-8	EL Berrueco, Cádiz	yes			
b	CO-6	Monte Izcar	no			
b	BA-2	Llerena	no			
b	M-3	Colmenar Viejo	no			
b	GU-8	Montarrón	no			
b	TO-2	Ventas Peña Aguilera	no			
b	CO-10	Albardado	no			
c	AB-1	Fuentealbilla	no			
d	MA-7	Sierra Utrera Karst	no			
d	GR-13	Otívar	no			
d	CA-9	Pila de Casares	yes			
d	TO-1	Torrecilla de la Jara	no			
d	M-2	Colmenar de Oreja	no			
d	MA-3	Alhaurín el Grande	no			
d	MA-4	Coín, Sierra Gorda	no			
d	MA-7	Jabonero	no			
d	BA-3	Llera	no			
d	BA-1	Alconera	no			
d	HU-7	Fuente de la Aliseda	no			

Tableau 11.3b: Assemblage chronologique 2b. Ce tableau correspond aux meulières citées dans les publications entre 1826 au début du XXe siècle. Les trois premiers sites sont mentionnés par (e) Miñano (1826-1829). La plupart des autres sont cités par (g) Madoz (1845-1850) Les cinq derniers (i) datant du XXème siècle, sont identifiés par des sources orales.

	Code	Site	Surveyed	Middle Ages	Modern			Contemporary	
					1500	1600	1700	1800	1900
e	M-4	Chapinería	no						
e	GU-2	Pinilla de Jadraque	no						
e	CC-1	Villars de Plasencia 1	no						
f	BA-4	Salvaleón	no						
f	GU-1	Brihuega	no						
f	MA-2	Teba	yes						
g	CC-4	Bohonal de Ibor	no						
g	CA-10	Peña Harpada	yes						
g	SE-3	El Hacho	yes						
g	GR-6	Alhama de Granada	yes						
g	GR-10	Véñez de Benaudalla	yes						
g	GR-11	Caniles	yes						
g	HU-6	Zalamea la Real	no						
g	CC-6	Logrosán	no						
g	CR-3	Chillón	no						
g	SE-5	Alanís	no						
g	CO-9	Los Arenales	no						
g	J-7	Linares District	no						
g	AL-9	Vera	no						
g	J-5	Andújar, Los Morales	no						
g	J-6	Andújar, El Pedroso	no						
g	J-3	Huelma-Solera	no						
g	CO-16	Minas de Espiel District	no						
g	CO-17	Fuente Obejuna Jud. Dist.	no						
g	SE-6	Villanueva de San Juan	no						
g	GU-6	Corduente	no						
g	GU-7	Castilnuevo	no						
g	B-5	Jerez de los Caballeros	no						
g	MA-6	Alozaina	no						
g	MA-5	Guaro	no						
h	CO-1	Cabra, Los Frailes	yes						
h	GU-5	Tobes	no						
i	CA-12	Benaocaz	no						
i	CA-4	Playa Aguadulce	yes						
i	CA-5	Roa Martín	yes						
i	CA-13	Guadalquitón	no						
i	HU-5	Cerro del Águila	no						

Tableau 11.4: Assemblage chronologique 3. Liste des 37 sites qui ne peuvent pas être datés avec précision. Selon la taille de leur extractions, plus de 1,00 m de diamètre, ils pourraient se situer entre le Moyen Âge à la période contemporaine. Pour les sites notés en gris, il n'y a pas d'indication d'exploitation pré-médiévale.

Code	Site	Surveyed	Neolithic Chalcolithic Bronze Age	Late Iron Age	Roman	Middle Ages	Modern	Contemporary
GR-8	Guajar Faragüit	yes						
GR-7	Padul, Los Guillares	yes						
GR-4c	La Merced 3	yes						
J-2	El Lachar	yes						
CA-6	Chipiona	yes						
CO-3	Carcabuey, Cudillas	yes						
CR-5	Granátula de Calatrava	yes						
CO-2	Cabra, Cortaores	yes						
AL-4	Guardias Viejas	yes						
GR-14	Ugíjar	no						
AL-5	Barranco Baena	no						
AL-6	Barranco Palancón	no						
AL-7	Los Loberos	no						
HU-2	El Prao de Abad	no						
HU-3	Las Malenas	no						
HU-4	La Obra Pía	no						
HU-1	El Campillo	no						
J-4	Cambil, Arbuniel	no						
CA-11	Salto de la Mora	no						
CO-4	Vega de los Molares	no						
CO-5	Baena, Molino de la Piedra	no						
CS-3	Borriol	no						
CS-2	Lucena del Cid	no						
MU-3	Cantera de los Porches	no						
CR-4	Pedrizas de Piédrola	no						
CC-5	Guijo de Galisteo	no						
CC-1	Plasencia	no						
CS -1	Soneja	no						
GU-3	Ruguilla, Cifuentes	no						
GU-4	Sigüenza, La Cuerda	no						
GU-9	Cobeta	no						
CU-1	Portilla, Los Molares	no						
V-1	Canals, Les Moles	no						
A-1	Sierra del Molar	no						
M-1	El Berrueco, Madrid	no						
M-5	Miraflores de la Sierra	no						

15.12. De la meulière au moulin : la distribution des meules

Dans notre étude, nous avons tenté de consacrer une section à la distribution des meules pour chaque période chronologique. Les données archéologiques, cependant, sont très déséquilibrées d'une période à l'autre. Par conséquent, une certaine précision ne s'applique qu'à la période romaine, fondée pour l'essentiel sur des meules inventoriées dans les musées. Le degré de précision pour la période contemporaine est également plus élevé, car il bénéficie de sources écrites. Les notions de distribution pour les autres périodes restent hautement spéculatives.

En général, les divisions traditionnelles de distribution en termes de « local, régional et longue distance » sont valables pour notre zone d'étude. Pour les périodes pré-romaines, le peu d'indices suggère surtout des distributions locales et quelques productions régionales.

Pour la période romaine, en se basant sur une série de distances théoriques entre les meulières potentielles et les lieux de découvertes des meules en particulier ceux liés aux roches volcaniques, on peut définir des limites arbitraires de 20 km pour les distributions locales, environ 80 km pour les distributions régionales et plus de 100 km (parfois atteignant plusieurs centaines kilomètres) pour les distributions de longue distance (fig. 12.8).

Le commerce à longue distance des meules recule vers la fin de l'Antiquité ou le début du Moyen Âge avec l'abandon des meules volcaniques et un « retour » aux productions locales et régionales de roches sédimentaires. Cela pourrait être lié au fait que les roches volcaniques étaient moins bien adaptées à de plus grandes vitesses de rotation, à l'heure de la grande expansion des moulins à eau. Mais cela est purement théorique dans notre zone d'étude parce que, comme nous l'avons souligné, des preuves de moulins romains et du haut Moyen Âge sont pratiquement inexistantes.

Par conséquent, les meulières locales et régionales vont dominer à nouveau le commerce des meules pendant des siècles, jusqu'à la période contemporaine. Il s'agissait surtout de petites productions de fournir les moulins environnants. Il y avait en ces temps, sans doute, aussi des meulières livrant des produits de qualité supérieure, qui ont sûrement fourni des moulins plus lointains. Néanmoins, il n'existe aucune preuve que ces meulières ont atteint la portée commerciale des productions volcaniques de l'époque romaine.

Vers le milieu du IXXe siècle, les conditions économiques et infrastructurelles du sud de l'Espagne étaient mûres pour l'arrivée, une fois encore, des importations de longue distance. À cette époque, ce n'était plus des roches volcaniques, mais des roches siliceuses provenant des meulières florissantes de France, en particulier du Bassin parisien. Ces meules françaises, bien que très coûteuses, ont changé la profession de la meunerie en réduisant le temps consacré à l'entretien et au rhabillage, et en augmentant considérablement le rendement et la qualité de la farine, en fournissant un pain fin et blanc de meilleur goût.

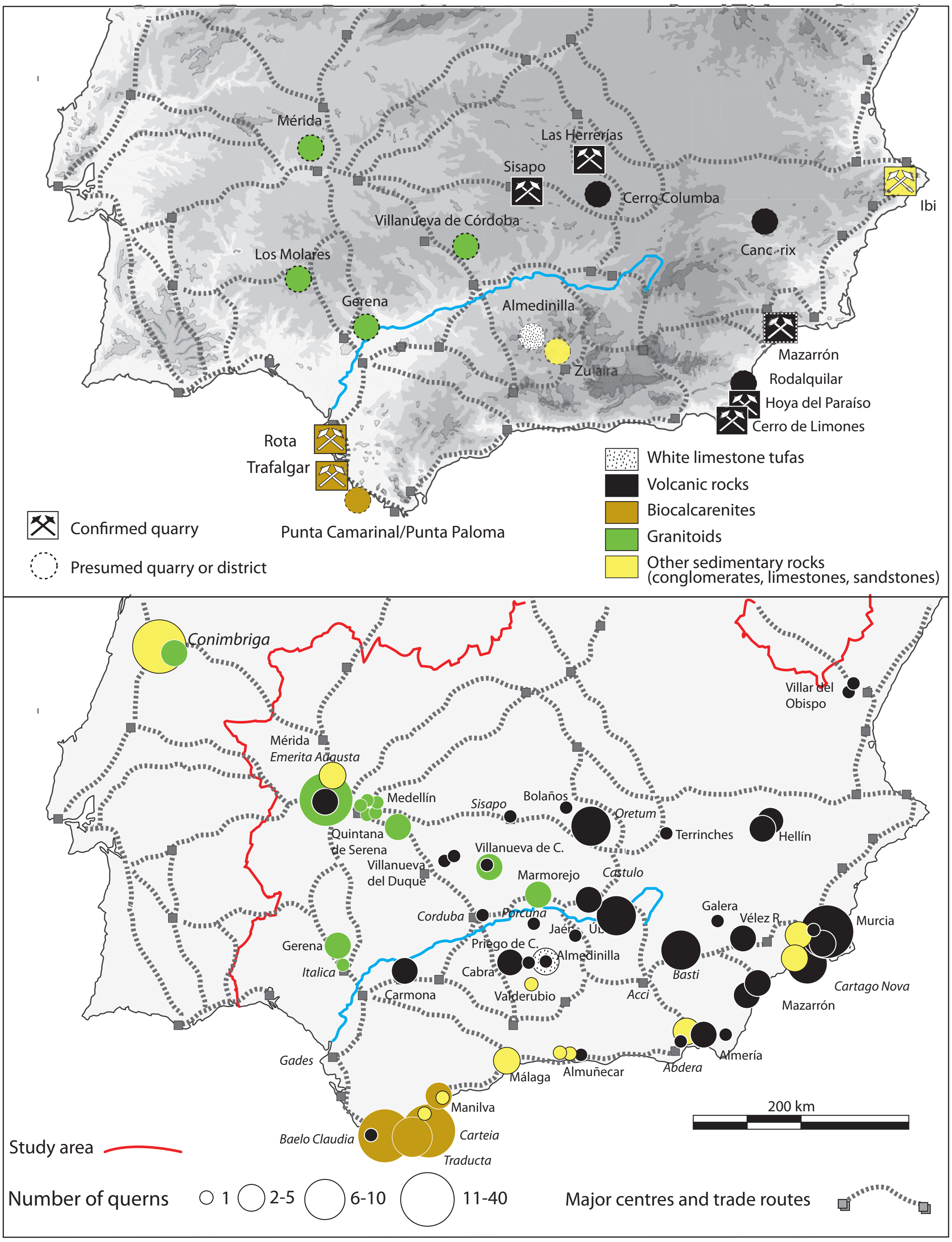


Fig. 12.8: Répartition de meules manuelles romaines par type de roche et nombre de pièces. La principale concentration de meules volcaniques se situe dans la partie orientale de notre zone d'étude, plus près de leurs sources. Le secteur sud, le long du détroit de Gibraltar, est dominé par biocalcarenites (ostionera), tandis que le secteur occidental est dominé par des granitoïdes (dessin T. Anderson).

15.13. De la pierre au pain

La présence de sable et de poussière dans le pain est aussi vieille que le pain lui-même. Cela résulte en partie du fait de ne pas nettoyer le grain correctement (Agustí 1722 : 187), et en partie des minuscules particules détachées des roches qui tombent dans la farine pendant le broyage. C'est un problème qui est reconnu dans notre zone d'étude depuis au moins le XVIe siècle (Gómez Ruiz 2003: 31). Toutes les pierres, dans une certaine mesure, étaient munies de ces particules qui usaient les dents des gens. Ce problème se produisait tout particulièrement après le rhabillage des meules (Agustí 1722 : 187), une routine qui devait être entreprise fréquemment et parfois de manière quotidienne. Au moins depuis la fin du Moyen Âge, il existe des preuves d'une volonté et de mesures prises pour libérer le pain de ces « impuretés ».

Dans de nombreux textes anciens, il y a des termes ou des expressions associés aux roches de meulières, aux partie des moulins, à la farine et au pain qui ont des significations différentes. « *Piedra blanca* » est synonyme à la fois de pierre blanche et de pierre tournante du moulin. Les mots désignant «sombre » (*bazo ou baza, baxo*) s'associent autant avec des roches de couleur foncée, qu'avec la pierre gisante du moulin (*piedra baza*). Ces connotations, comme nous l'avons noté, vont au-delà des définitions simples des pierres, des meulières, de la farine et du pain et ont des conséquences sociales et économiques. Le pain blanc (*pan blanco*) est traditionnellement associé à la noblesse et au clergé, tandis que du pain noir (*pan moreno, bazo, baxo*) était le pain des classes inférieures.

En dépit de toute l'habileté et de l'expérience d'un meunier, une farine blanche ne pouvait pas être atteinte avec toute sorte de grain ou toute sorte de meules. La céréale qui se prête le mieux à la production de pain blanc, en raison de son albumen farineux, était le blé tendre, un grain qui était facilement accessible dans le sud de l'Espagne.

La condition pour obtenir du pain blanc est une bonne séparation de l'endosperme blanc du son et du germe. Cela dépend beaucoup de l'expérience du meunier et de sa capacité de déterminer la quantité d'eau à ajouter aux grains avant la mouture afin de faciliter la séparation et de contrôler la quantité de la « lumière » laissée entre la pierre tournante et la gisante de manière à assurer une mouture plus fine ou plus grossière. C'est le meunier qui décidait également quand il fallait accélérer ou ralentir la rotation des pierres, et quand il fallait arrêter la procédure pour les aiguiser. Enfin, c'est le meunier qui déterminait si la farine avait besoin d'un second tour de mouture, et le choix des tamis pour atteindre le calibre désiré de farine. En dépit de toutes les capacités du meunier, un pain blanc ne pouvait pas être atteint par n'importe quel type de roche. L'avantage des calcaires blancs, tels que ceux de Moclín (GR- 1) à Grenade et Berrueco (CA- 8) à Cadix, et certainement celle de Colmenar de Oreja (M-2) à Madrid, est que la poussière libérée dans la farine était blanche et donc n'aurait pas affecté la couleur du pain (Belmont 2011: 15). En ce sens, l'avantage de roches blanches n'était pas l'absence de poussière dans la farine, mais la perception de son absence.

15.14. Observations finales et perspectives

Le principal objectif de cette recherche est faire un premier bilan de l'histoire de la productiondes meules dans les carrières, de la protohistoire à l'époque moderne, un projet qui n'a jamais été entrepris dans le sud de l'Espagne. Le terme « moderne » dans le titre de cet ouvrage, doit être interprété dans son sens large, correspondant à la transition du IXXe au XXe siècle, lors du déclin de la production de meules dans la péninsule ibérique, en tant qu'industrie, tout d'abord à la suite de l'introduction des meules siliceuses depuis la France (*meulas francesas*), toujours visibles aujourd'hui décorant des espaces publics partout en Espagne. Elles étaient un cran au-dessus des meules produites en Espagne (et le reste de l'Europe). L'effondrement ultime de la production des meules dans la péninsule arriva avec l'introduction dans le cours du XXe siècle du rouleau en acier, qui va inexorablement précipiter la fin non seulement de l'industrie meulière, mais de la meunerie traditionnelle.

Comme nous l'avons indiqué à plusieurs reprises, de nombreuses recherches restent encore à entreprendre sur les meulières et les meules dans le sud de l'Espagne. Nous avons seulement été en mesure de visiter environ un tiers de sites que nous avons identifiés (et il y en a certainement encore beaucoup à trouver). Il faut noter que ces visites ont été le plus souvent trop courtes pour documenter les sites de manière précise.

En outre, dans la perspective d'établir dans l'avenir une chrono-typologie des meulières et de leurs produits, il est nécessaire de définir des objectifs de recherches coordonnées, dans la ligne des travaux récents entrepris par le « Groupe Meule » en France ou du projet de recherche « Norwegian Millstone Landscape » en Norvège qui ont combiné des études des meulières, des études de meules dans les musées et des recherches dans les archives historiques avec des analyses pétrographiques. Peindre un portrait plus précis des nouveaux membres du « club » européen des meulières volcaniques romaines (la Province volcanique du sud-est et la province volcanique de Calatrava) nous parait aussi essentielle.

Comme beaucoup d'autres éléments du patrimoine culturel, les meulières méritent la reconnaissance et devraient être enregistrées et cartographiées. Les autorités doivent être informées de leur existence afin que leur soient attribuée la même protection et reconnaissance que tout autre monument du patrimoine culturel. Bien trop souvent, ces meulières, parfois spectaculaires avec leurs visages tubulaires, ont été négligées ou, pire encore, ont été détruites. Il faut noter qu'aucune meulière dans notre zone d'étude n'a été l'objet d'une véritable valorisation expliquant au moyen de pancartes les différentes étapes des production.

Espérons que, en dépit des conditions économiques difficiles que la société connaît actuellement, ce nouveau domaine de recherche ne sera pas placé dans un tiroir, comme cela s'est produit après la brillante recherche sur les meules initiée par Fernando de Avilés dans les années 1940 (Berrocal 2007). Il faut reconnaître que le sujet de production des meules est essentiel à la compréhension de l'histoire de la nutrition de l'homme. C'est notre désir que la récente table ronde internationale qui a eu lieu à Arbeca, en Catalogne, réunissant des chercheurs d'Espagne et de la France pour partager l'état de recherche sur les meules et meulières de l'âge du Fer soit un point de départ dans cette direction.